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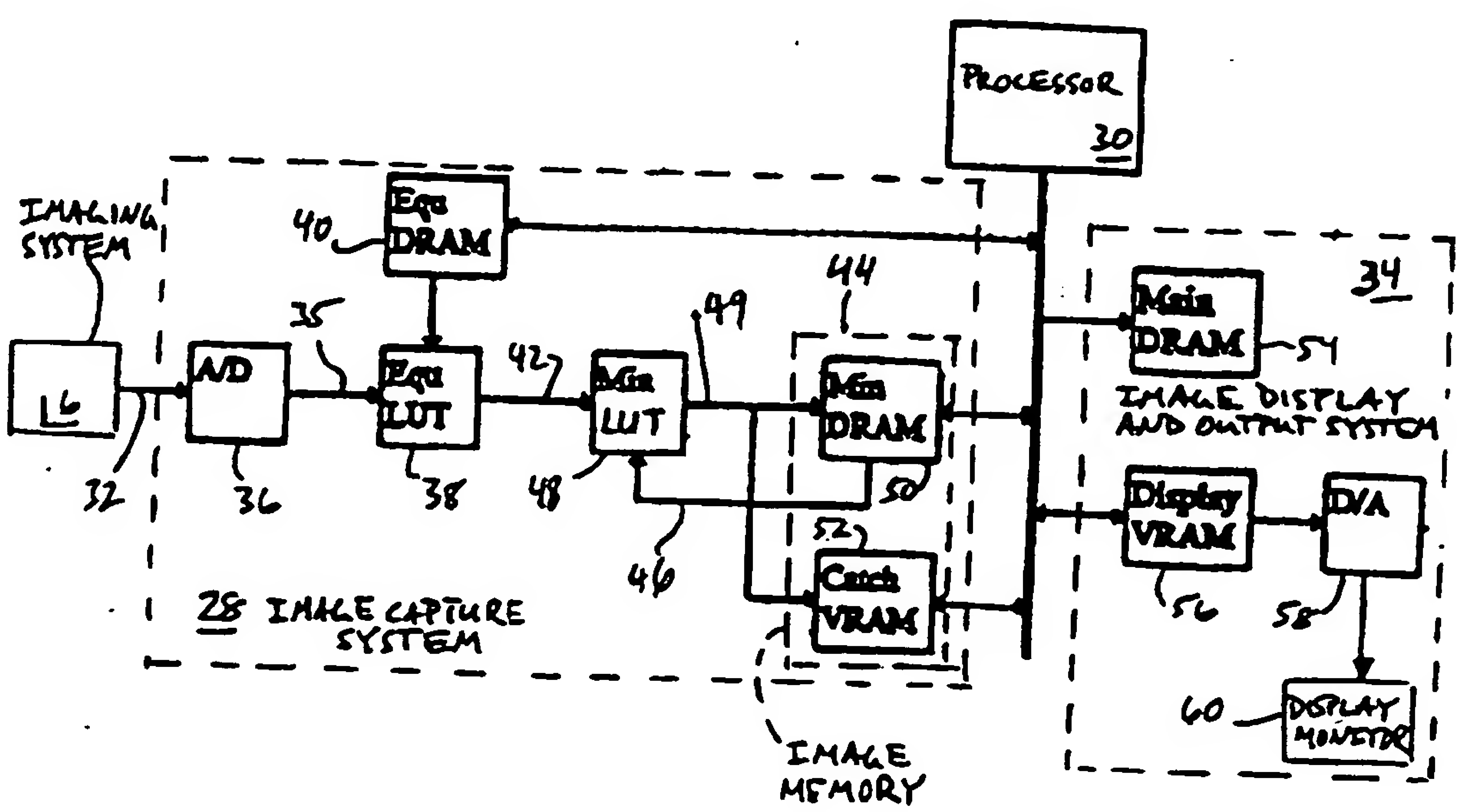

(57) Abstract

A fingerprint image capture system (28) reduces tip smear by ceasing to update a data array characteristic (44) of the rolled fingerprint image behind an advancing freeze column at least about half way from the trailing edge to the leading edge of a finger contact strip.

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METHOD AND DEVICE FOR REDUCING SMEAR IN A ROLLED FINGERPRINT IMAGE

Background of the Invention

The invention relates to electronic fingerprint image capture systems, and, in particular, to a method of reducing smearing in a captured rolled fingerprint image.

The traditional method of obtaining a fingerprint image is to first apply ink to a subject's finger, and then to transfer the fingerprint pattern of ridges and valleys to a piece of paper by pressing the finger to the paper. The fingerprint pattern of ridges transfers to the paper, while the valleys do not. To obtain a rolled fingerprint image, a side of an inked finger is placed in a designated area of the paper and then the finger is rolled to its other side on the paper.

Opto-electronic systems can capture a rolled fingerprint image without the use of ink. Typically, a series of optical images of a rolling finger on an imaging surface are propagated from an imaging device and converted to digital data. A variety of methods can be used to generate a rolled fingerprint image from the digital data representative of the series of images. One method is disclosed in U.S. Patent No. 4,933,976. According to this method, the propagated images are sequentially stored in the form of digital arrays of image data. Active areas of the arrays representative of fingerprint features are identified as a mathematical function of the stored image data. If adjacent two-dimensional active areas have sufficient overlap, then they are merged according to a mathematical function of the data in the overlap region to form a composite array characteristic of the rolled fingerprint image. The mathematical function in the composite array generating step is an average, a comparison or an average and a

comparison of the overlapping data in adjacent active areas.

Another method is used in the model TP-600 system, produced by Identix, Inc. of Sunnyvale, California. The TP-600 includes an optical system having a large charge coupled device (CCD) imager that accommodates the entire imaging surface of an optical platen. The CCD output is an analog signal characteristic of light and dark patterns on the imaging surface. When a finger is placed on the platen, the analog signal has lower values (darker) for fingerprint ridge information and higher values (lighter) for fingerprint valley information, similar to what occurs when ink is used for fingerprinting. The analog signal is applied to an analog-to-digital (A/D) converter, the output of which is digital image data used to update the content of an array in image memory by means of a minimum function. Each element in the array initially has a value that represents the light intensity imaged at a corresponding location on the platen. As the finger is rolled across the imaging surface of the platen, the data in the image memory is developed and updated.

The minimum function operates by preserving pixel values in image memory that are lower than the corresponding values of the incoming image data. If the value of the current image data is lower than the corresponding pixel value in image memory, then the lower image data value displaces the higher value in the array. Thus, for every location where a finger ridge contacts the imaging surface a lower pixel value (darker) is preserved in image memory. The contents of image memory are output to peripheral devices for storing a captured rolled fingerprint image and for real-time display of the developing rolled fingerprint image.

While using the minimum function method of acquiring a rolled print by saving the darkest intensity value will produce a good quality print, free of recognizable artifacts, and will be insensitive to the speed with which the finger is rolled, some areas of the print tend to have a smeared characteristic, reducing the differentiation between ridges and valleys. This effect occurs where the finger slides on the imaging surface while still in contact. The smearing often occurs at the tip of the finger and at the edge of the contacting area. The use of tacky coatings on the contact surface reduces overall slippage, but the rounded geometry of the finger makes tip smear a continuing problem. While smearing is found in inked prints as well as those obtained by the opto-electronic system, it would be advantageous for the opto-electronic systems to improve the clarity of the image in the areas in which slip occurs.

Summary of the Invention

The invention provides a method of reducing smear in a rolled fingerprint image represented by a rolled image array. The method includes the step of generating a series of frames of an optical image signal, wherein the optical image signal includes data characteristic of light intensities of corresponding locations of an optical image, wherein the optical image includes a fingerprint image of a finger rolling on a surface. The method also includes determining, for each frame of the optical image signal, a freeze column representing a line positioned between leading and trailing edges of the fingerprint image and oriented transverse to a direction of roll of the finger. The method further includes sequentially updating an interim array that is an accumulation of the frames of the optical image signal and characteristic of an interim image of a rolled

fingerprint. A current update of the interim array is formed by reducing pixel values of the interim array with a portion of the difference between the corresponding data values from the current frame of the optical image signal and the pixel values of the interim array only if the corresponding data values of the current frame of the optical image signal are less (characteristic of darker features) than the corresponding pixel values of the interim array. The rolled image array is generated by transferring portions of the interim array to the rolled image array in concert with the movement of the finger image in the optical input signal.

During each update cycle, a new freeze column is determined at a position near a midpoint of a finger contact area which in turn is determined from the leading and trailing edges of the fingerprint image associated with a current frame of the optical image signal. The rolled image array may be initialized with a trailing portion of a current interim array, the trailing portion being interim array data behind a current freeze column in a direction of finger roll. Each time a new freeze column is determined by a processor in the system, current interim array data between the current freeze column and the previous freeze column is transferred to the rolled fingerprint image array. Alternatively, current interim array data between the previous freeze column and data characteristic of the leading edge of the rolled fingerprint in the interim image is transferred to the rolled fingerprint image array each time a new freeze column is determined. In both cases, the trailing portion of the interim array behind the previous freeze column is not used to further update the rolled image array. Thus, the data in the rolled image array is frozen behind a freeze column that moves in the direction of finger roll and smearing in the rolled fingerprint

image due to finger movement behind that column is eliminated.

In addition to eliminating smear in the rolled fingerprint image behind the freeze column, the invention preserves the benefits provided by the minimum function in merging a series of frames of the image data signal.

Brief Description of the Drawing

The accompanying drawings, which are incorporated and constitute a part of the specification, schematically illustrate an embodiment of the invention and, together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

Fig. 1 is a perspective view of an image capture device.

Fig. 2 is a diagrammatic illustration of the prior art rolled fingerprint optical imaging system of the image capture device illustrated in Fig. 1.

Fig. 3 is a functional block diagram of the image capture device of Fig. 1.

Fig. 4 is a functional block diagram of a portion of the image capture device of Fig. 1.

Figs. 5A-E illustrate a series of optical images of a finger rolling on a platen.

Figs. 6A-6E illustrate a series of images represented in the image memory shown in Fig. 3 by an interim data array. The images temporally correspond with the images illustrated in Figs. 5A-5E, respectively.

Figs. 7A-7E illustrate a series of images represented in output DRAM by a rolled fingerprint image array. The images temporally correspond with the images illustrated in Figs. 6A-6E, respectively.

Figs. 8A-8E illustrate a series of images represented in display VRAM by a rolled fingerprint image

array. The images temporally correspond with the images illustrated in Figs. 6A-6E, respectively.

Detailed Description of the Invention

A smear reduction method for reducing the effects of smearing in rolled fingerprint images is provided. Referring to Fig. 1, the smear reduction method may be incorporated into the operation of a model TP-600 fingerprint capture device 10, manufactured by Identix, Inc., the assignee of the subject matter of this application.

The TP-600 includes separate imaging systems for obtaining a rolled fingerprint image and for obtaining a plain, or slap image. The plain fingerprint imaging system 12 produces an analog signal representing the image of one or more fingers pressed to a plain print platen 14, and a rolled fingerprint imaging system 16 that produces an analog signal representing the image of a finger 18 being rolled across a rolled print platen 20. Referring now also to Fig. 2, each imaging system includes an illumination source 22, optics 24, and a large CCD imaging device 26 that accommodates the entire image from the platen surface. In the described embodiment, the CCD imaging device 26 for the rolled fingerprint image is a model TC217 CCD imaging array, available from Texas Instruments, Inc. of Dallas, Texas. Although only one mirror is shown in Fig. 2, optics 24 actually includes a combination of prisms, mirrors, and lenses selected and arranged to bring the image from the platen surface to the CCD imaging device 26. The plain print platen 14 is wider than the rolled print platen 20 to accommodate four fingers rather than one finger on its surface, and its optics 24 are arranged differently to accommodate the larger imaging surface. The purpose of each system is to present a fingerprint image at the

surface of a CCD imaging device when a finger is applied to the imaging surface of the platen.

Referring now to Fig. 3, the output of the CCD imaging device 26 is an analog signal 32 which is applied to an image capture system 28. The illumination and imaging, and the CCD output convention employed present an image signal that has lower values (darker) for ridge information and higher values (lighter) for valley information.

A processor 30 is used to manage the transport of data between and through each functional element of the system and to perform other "housekeeping" functions such as writing text to an image display monitor 60 in the image display and output system 34, intercepting switch closures and performing system start-up and shut-down operations. As will be described in greater detail below, the processor 30 also actively manages the processing of image data as the finger is rolled on the platen surface in forming a rolled fingerprint image. For the described embodiment, a graphic processor manufactured by Texas Instruments, Inc., part number TMS34020, is used. This particular processor supports special functions for processing two-dimensional arrays in memory. A copy of the source code in C language for operating the TP-600 is included in the microfiche appendix.

Referring now also to Fig. 4, the analog signal 32 from the CCD imaging device 26 of the imaging system 16 is applied to an analog-to-digital (A/D) converter 36 that is part of image capture system 28. Because the illumination of the fingerprint is not uniform in the scanner, the data values of the A/D output digital data 35 are individually scaled by an equalization look-up table (Equ LUT) 38 according to table values stored in the equalization memory (Equ DRAM) 40. The stored

reference values correspond to an image of the surface of a blank platen 20, smoothed to eliminate noise and surface contamination.

The output from Equ LUT 38 is an optical image signal 42 in the form of a stream of digital data that can be grouped in frames. The data have values which are characteristic of the light intensity of corresponding locations of the imaging surface of the platen 20. Each frame corresponds to an image of the platen at a different time. The data values are updated about fifteen times a second. Thus, about 25-35 frames of optical image signal 42 are generated during the time it takes for the finger 18 to roll across the surface of the platen 20.

The optical image signal 42 is used to update the content of an image memory 44, which holds a 968 X 968 pixel interim data array, by means of a functional element identified as a "minimum function" look-up table (Min LUT) 48. This size array is sufficient to produce an image with a resolution of 600 dots per inch. The inputs to Min LUT 48 are the A/D converter output 35 as modified by Equ LUT 38, which is the current optical image signal 42, and the corresponding old interim data array pixel values 46 which are to be updated. The "latest value" is input from the current frame of optical image signal 42 and the "old value" is input from the current interim data array, as most recently updated by the previous frame of optical image signal 42.

In the simplest implementation, the Min LUT 48 computes $F^n_{i,j}$, the new pixel value 49 of the interim data array at row i and column j, as a minimum, $F^n_{i,j} = \min(I^n_{i,j}, F^{n-1}_{i,j})$, where I^n is the input datum value of the nth frame from the Equ LUT 38 and $F^{n-1}_{i,j}$ is the feedback 46 from the image memory 44 from the preceding frame. The output signal 49 of Min LUT 48, for each pixel of interim

data array, is the lower value of its two inputs, as suggested by its name. For each datum output by the A/D converter 36 (as modified by Equ LUT 38 to form optical image signal 42), the corresponding pixel of interim data array in the image memory 44 is updated.

It is not necessary to store the digital data 35 output from A/D converter 36 and the optical image signal 42 from Equ LUT 38 as arrays before being processed by Min LUT 48. The values of output data 49 from Min LUT 48 used to update the interim data array depend only on the corresponding datum values of the optical image signal 42 and on the old corresponding pixel values 46 of interim data array. For every location where a finger ridge contacts the imaging surface of the platen 20, a lower pixel value (darker) is preserved. The result of this technique is that as the finger 18 is rolled across the imaging surface of platen 20, an interim rolled fingerprint image is constructed in image memory 44. This process has been found to eliminate artifacts such as fingerprint features or discontinuities that are not part of the true fingerprint.

When performing a capture of a rolled fingerprint image, the interim data array in image memory 44 must be initialized since feedback is involved. One way to initialize image memory 44 is to set all the pixel values to a maximum value. Then the interim data array in image memory 44 will immediately reflect any data that is input in the next frame. In another embodiment, interim data array can be initialized by setting up Min LUT 48 as a straight-through function such that its output is the same as the optical image signal 42 input from the Equ LUT 38. The first frame of optical image signal 42 can then update the image memory 44 independently of what is already stored.

As the finger 18 is rolled, the edges of the contact area of the finger on the platen may move fairly rapidly with respect to the frame update rate. This may cause some discontinuities to occur between the interlaced fields of the video. Similarly, the tip of the finger often slides as it contacts the platen, causing discontinuities. To resolve this problem, the function loaded into the Min LUT 48 can be modified from a strict minimum such that when the input datum value I^n is less than the previous interim array value F^{n-1}, the interim array value is reduced by a portion of the difference, $F^n = F^{n-1} - K*(F^{n-1} - I^n)$, where K is a factor less than or equal to one that sets how fast the value in a pixel may change. Noticeable improvement in the image quality can be obtained with K in a range of 0.25 to 0.5. For the described embodiment, K is set to approximately 0.33. This function causes the conditions of concern to appear as gray smears instead of jagged discontinuities, since the conditions are often only present for a small number of frames.

The Min LUT 48 has a 64 Kb x 8 SRAM and registers to pipeline the input and output. A 64 Kb address space requires 16 address lines. The two 8-bit inputs to the Min LUT 48 are tied to 8 address lines each. Thus, for each set of the two input values there is one corresponding location in the SRAM which contains the desired value to be output. This implementation is very unrestrictive, since any function can be implemented in a tabular form. The different functions to be used in the Min LUT 48 are typically precomputed and stored in a Main DRAM 54 and then loaded into the SRAM when needed.

Image memory 44 includes two redundant memories, Min DRAM 50 and Catch VRAM 52. They independently and simultaneously hold the same interim data array for transfer to image display and output system 34. Image

display and output system 34 includes a main output memory 54 (located in Main DRAM) and a display memory 56 (located in Display VRAM) that receive data transferred by processor 30 from Min DRAM 50 and Catch VRAM 52, respectively. The display memory 56 is used to provide information to the operator in real-time. The display memory 56 receives image information along with fingerprint placement cursors and text information providing instructional information to the operator. The display memory 56 typically contains less information than that contained in image memory 44 or output memory 54 for reasons of data efficiency, display raster size, and other display limitations. The output memory 54 does not contain text information and finger placement cursor information. This memory contains all the high quality image data.

The interim data array in image memory 44 represents an interim rolled fingerprint image, and could be transferred in its entirety with each frame to output memory 54 or display memory 56 to form a rolled fingerprint image array. This is the method of the prior art TP-600. However, if the finger 18 slips on the imaging surface of the platen 20 when the interim data array is being formed, then the rolled fingerprint image will appear smeared, similar to what happens with the ink and paper method of obtaining a rolled fingerprint image. The smear reduction method of the invention reduces smearing in the rolled fingerprint image by transferring to output memory 54 and display memory 56 only a selected portion of the interim data array 46 with each video frame.

Typically, an operator will preview the finger image prior to entering a capture mode to obtain the rolled fingerprint image. In order to place the finger 20 properly on the platen 18, it is helpful to be able to

center the finger while viewing the image of the finger on a display monitor 60. The operator sets Min LUT 48 to the straight-through function and rolls the finger to one side to prepare for the capture of the rolled image. The image displayed is then not a rolled image but a direct image of the finger 18 on the platen 20. Since the capture mode is entered after a scan button is pressed, the data in the image memory 44 at the end of the preview mode serves to initialize that memory for the capture.

Referring now to Fig. 5A, the first frame of optical image signal 42 after capture mode is entered represents an optical image 62a of the surface of the platen 20, including an image of contact area 64a of the finger 18 on platen 20. (The cross-hatching in the drawing indicates fingerprint features.) In Fig. 5B, contact area 64b is to the right of the location of contact area 64a, indicating that the finger 18 has rolled to the right. The contact area 64 continues to move incrementally to the right in Figs. 5C and 5D. In Fig. 5E, the contact area 64e has shrunk in size from previous contact area 64d, as the finger 18 is lifted from the platen 20.

As the capture mode is entered, the Min LUT 48 is restored to the modified minimum function, as described above. Referring now also to Fig. 6A, the most recent frame of optical image signal 42 that was passed through Min LUT 48 becomes an initial frame of interim data array, which is characteristic of an interim image 66a that includes interim rolled fingerprint image 68a. Interim rolled fingerprint image 68a, in this embodiment, is the same as the corresponding contact area 64a illustrated in Fig. 5A. Alternatively, interim data array can be initialized with all high pixel values, indicative of a blank, illuminated platen (not shown). Min LUT 48 can then update interim data array using the

modified minimum function, with a first frame of optical image signal, represented by optical image 62a, as one input and corresponding pixel values of the "blank" interim data array as the other input. The resulting interim data array is essentially the same in either case.

The interim data array is next updated when the second frame of optical image signal 42, represented by optical image 62b in Fig. 5B, is processed through Min LUT 48 with corresponding pixel values 49 of the interim data array, represented by the previous interim image 66a. The updated interim data array is now characteristic of an interim image 66b that includes interim rolled fingerprint image 68b, illustrated in Fig. 6B. Similarly, Fig. 6C illustrates interim image 66c and interim rolled fingerprint image 68c, which are represented by interim data array in image memory 44 after being updated with the next frame of image signal 42, which is represented by optical image 62c, illustrated in Fig. 5C. Figs. 6D and 6E illustrate respective interim images 66d, 66e and interim rolled fingerprint images 68d, 68e represented by subsequent updates to interim data array.

Contact area detection can be done in many ways. One method is to finely segment the optical image signal 42 and then compute the variance of the data values in each of the segments. A segment with a small variance is considered to have no contact. Another way is to threshold each data value and to consider it contacted when the value drops below a fixed level. This is acceptable when the image background is equalized by Equ LUT 38 since then a fixed level corresponds to a consistent degree of contact across the complete image.

The bottom or tag bit (bit 0) of interim data array in image memory 44 is allocated to the function of

indicating contact. Since Min LUT 48 is completely flexible as to what is programmed into it, the function for the tag bit 0 may be handled separately from bits 1-7. The tag bit is set to 1 if the input value to Min LUT 48 from optical image signal 42 is less than a threshold T. The information reflecting the contact area 64 is thus available in the tag bit 0 of the Min DRAM 50 and Catch VRAM 52 as a binary images 70a-70e, which have outlines indicated in Figs 6A-6E, respectively, by dashed lines. The accumulated gray-scale interim images 66a-66e are available in the upper bits 1-7 of the Min DRAM 50 and in the Catch VRAM 52 of image memory 44. It will be understood that the processor 30 can determine the binary images 70a-70e even when Min LUT 48 is in preview mode in which the optical image signal is passed through to image memory 44.

The contact area 64 of the fingerprint represented by each frame of optical image signal 42 can be modeled most simply by a contact strip 72, with a left edge 74 and a right edge 76. The contact area 64 usually has a convex perimeter, but we have found it acceptable to consider contact strip 72 to be rectangular-shaped, with the left edge 74 as the column at the left-most edge of the contact area 64 and the right edge 76 as the column at the right-most edge of the contact area 64. The processor 30 determines the right edge 76 and left edge 74 of the contact strip 72 from binary contact image, generally referred to by reference numeral 70, in the Catch VRAM 52. This is done in a time frame comparable to the frame update rate in order to keep up with the rolling finger.

One way to determine the contact strip 72 is to examine one row of tag bits across the center of the binary contact image 70. The left-most tagged pixel is found by searching for the first tagged bit in the row

from the left edge of interim data array, and the right-most tagged pixel is found by searching for the first tagged bit in the row from the right edge of interim data array. The left edge 74 and right edge 76 of the contact strip 72 are then identified with the left-most tagged pixel and the right-most tagged pixel.

Dirt or contaminants present on the platen 20 can cause isolated pixels out of the contact area 64 to be tagged in forming the binary contact image 70. The fingerprint is composed of ridges which may align with the line being checked such that a valley will confuse the location of an edge. These problems can be reduced by examining a vertical band 78 that includes a number of horizontal lines near the center of the binary contact image 70. For example, a vertical band 78 of 10 lines spaced 4 lines apart across the middle of the binary contact image 70 can be used.

Using only the left-most tagged pixel as the left edge 74 of the contact strip 72, even when using more than one line near the center of the binary contact image 70, can still be too sensitive to the presence of dirt and falsely indicate contact or distort the finger image at the edges of the contact area 64. To mitigate this problem, in one embodiment, a number of tagged pixels are counted from the left side of the binary contact image 70 before establishing a column as the left edge 74 of the contact strip 72. The processor 30 determines the right edge 76 of the contact strip 72 in a similar procedure. The left and right edges 74, 76 of the contact strip 72 are established as the 10th tagged pixel in from the outside edges.

The processor 30 supports a special mode which allows processing operations to be performed during a two-dimensional block transfer. One of the operations is a logical OR. Thus a number of rows may be transferred

to one final row while performing a logical OR. The destination row thus provides an indication of the contact strip over a band 78 instead of a single line.

By identifying the contact strip 72, the processor 30 is able to perform several other new functions. It keeps track of the left edge 74 and right edge 76 of the contact strip 72, and determines when the finger 18 is placed upon the blank platen 20, when the finger 18 is rolled and in what direction, and when the finger 18 is lifted from the platen 20.

When the finger 18 is initially placed on the blank platen 20, the left edge of the finger contacting the platen will be beyond the right edge in a direction from right to left. As the finger 18 is placed down, the contact strip 72 will have a positive width between the right edge 76 and the left edge 74. As long as the left edge 74 of the contact strip 72 keeps going left and the right edge 76 of the contact strip 72 keeps going right, it can be considered that the finger 18 is still in the process of being placed on the platen 20, with the contact strip 72 growing. If the finger 18 is already on the platen 20, the contact strip 72 will start at a positive value. This is the most common situation, when the preview mode is used to place the finger 18 and roll it back to the starting position. The finger 18 usually is not raised again before the capture mode is started.

The processor 30 determines that the rolling of the finger 18 has begun when one edge of the contact strip 72 starts to go inward instead of outward. For example, when the left edge 74 starts to go right, as illustrated in Figs. 6A-6D, the processor 30 determines that the finger 18 is being rolled right, in which case the right edge 76 is the leading edge and the left edge 74 the trailing edge of the rolling finger. If, instead, the right edge 76 begins to go left, the processor 30

determines that the finger 18 is being rolled left, in which case the left edge 74 is the leading edge and the right edge 76 is the trailing edge of the rolling finger. A small tolerance for jitter is allowed by determining that rolling is begun when the left edge 74 (or right edge 76) of the contact strip 72 moves back from its most extreme position by a small number of pixels, nominally 5. If the left edge 74 is moving right and the right edge 76 moving left for a predetermined number of frames, then the processor 30 determines that the finger 18 is being lifted from the platen 20.

The processor also determines from each frame of image signal 42 a freeze column 80 which corresponds with a position in the contact area 64, or binary image 70, located between the left edge 74 and right edge 76 of the contact strip 72 for each frame. In one embodiment, the freeze column 80 corresponds to a position located approximately half the distance from the trailing edge to the leading edge. In another embodiment, the freeze column corresponds to a position located more than half the distance from the trailing edge to the leading edge.

Instead of transferring the entire interim data array to output memory 54 only after the finger 18 is finished rolling across the image platen 20, as was done with prior art embodiments of the TP-600 device, the porocessor 30 transfers a portion of the interim data array to output memory with each new frame as the finger rolls. The processor 30 ceases to update a portion of a rolled fingerprint image array in output memory 54 behind the freeze column determined from the preceding frame of optical image signal 42. The freeze column 80 moves in increments from frame to frame with the right and left edges 76, 74 of the contact strip 72 in the direction of roll. Since the data in the developing rolled fingerprint image array behind the freeze column 80 is

not updated, any image smearing that develops in a trailing portion of the interim image 62 represented by the interim data array does not show up in the rolled fingerprint image array.

Referring now to Fig. 7A, an output rolled fingerprint image array in output memory 52 is initialized with high pixel values indicative of a blank background 82a. Referring now also to Fig. 7B, when the finger 18 starts to roll, the processor 30 updates the output rolled fingerprint image array in output memory 54 by transferring a trailing portion of interim data array from image memory 44. The trailing portion can be, e.g., the trailing portion of interim data array characteristic of interim image 66b, starting with a column corresponding to the trailing edge 74 of the contact strip 72, up to and including the freeze column 80 determined from the current optical image signal. Output rolled fingerprint image array at this point is indicative of rolled fingerprint image 82b, which includes transferred portion image 84b. As the finger 18 rolls, the processor 30 updates the output memory 54 to keep up with the position of the approximate center of the moving contact strip 72.

Each subsequent update to the rolled fingerprint image array in output memory is a portion of interim data array block-transferred from image memory 44. In one embodiment (*see* Figs. 8A-8E and related discussion *infra*), the transferred portion of a current interim data array is characteristic of the interim rolled fingerprint image 68 up to approximately the leading edge, i.e., up to a column of the interim data array corresponding to the leading edge of the current contact strip 72. In another embodiment illustrated in Fig. 7C-7D, the transferred portion of the current interim data array from image memory 44 is narrower, and extends only

up to approximately the freeze column 80 of the current optical image signal. Fig. 7C illustrates output rolled fingerprint image 82c, with transferred portion image 84c, after a corresponding portion of the current update of interim data array (see Fig. 6C) is transferred to the output rolled fingerprint image array. The transferred portion of interim data array in this instance includes all data to the right of freeze column 80b, i.e. in the direction of finger roll, up to and including freeze column 80c. Similarly, output rolled fingerprint image 82d, illustrated in Fig. 7D, is represented by the output rolled fingerprint image array subsequent to a portion of a subsequent update and interim data array (see Fig. 6D) being transferred. The transferred portion includes all data to the right of freeze column 80c up to and including freeze column 80d.

For the final update to the rolled fingerprint image array in output memory 54, the transferred portion extends from a column of interim data array corresponding to the freeze column determined from the preceding optical image signal 42 to at least the column of interim data array corresponding to the most extreme position of the leading edge of the contact strip 72. In all cases, the transferred portion of the current interim data array is characteristic of the interim rolled fingerprint image 68 forward from the line represented by the freeze column 80 derived from the preceding optical image signal 42. For example, the final transferred portion, characteristic of transferred portion image 84e illustrated in Fig. 7E, is data interim data array which is characteristic of a portion of interim image 66e forward in the direction of finger roll from the previous freeze column 84d.

Thus, the processor 30 freezes the output memory 54 behind the moving freeze column 80, which is

characteristic of a vertical line corresponding to the approximate center of the moving contact strip 72. No updating of the output memory 54 occurs behind that line. While this does not eliminate tip smear, it reduces it by about 50-60%. The smearing in the main part of the fingerprint due to the movement of the back edge of the finger is eliminated. Since smear can still occur between the leading edge and the freeze column 80, the method can be improved by setting the freeze column 80 at a position closer to the leading edge, nominally five-eighths (5/8) of the distance between the trailing and leading edges.

The processor 30 tracks the progress of the leading edge of the contact strip 72, which is the right edge 76 in the embodiment illustrated in Figs. 5-7. When the leading edge retreats from its farthest position by a selected number of columns as the finger 18 is lifted from the platen 20, the processor 30 determines that the capture is completed, performs the final update to the output memory 54, and ceases to update the rolled fingerprint image array in output memory 54 any further. This prevents smear as the finger 18 is lifted from the platen 20. Thus, when the finger 18 lifts from the platen 20 or rolls backwards, the processor updates the output memory 54 with the forward portion of the interim data array and ceases any further updates.

It is important to note that the processor 30 only passes though a portion of the contents of the image memory 44 to the output memory 54 at any time. This portion corresponds to a narrow strip of the interim data array located adjacent to, but not overlapping with, the freeze column defined by the previously passed through data. It is also worth noting that the data used to update the output memory 54 is not representative of a raw fingerprint image. Rather, the transferred data is

representative of the interim rolled fingerprint image 68 produced by the Min LUT 48 in that narrow strip 84 since the finger 18 began to roll.

A rolled fingerprint image is displayed as it is captured. The processor moves data to the display memory (VRAM) 56 from the Catch VRAM 52 in image memory 44. The data is then converted to video format through a digital-to-analog converter (D/A) 58 and output to display monitor 60. In the embodiment depicted in Fig. 4, the display monitor has a display area formed by a 720 X 720 pixel array. The processor 30 decimates the image by one pixel column out of four and one row out of four during the transfer from the Catch VRAM 52 to the Display VRAM 56 to fit the image into the display format.

Referring now to Figs. 8A-8E, the processor 30 updates the display memory 56 (in the reduced format described above) from the image memory 44 while the finger 18 rolls on the platen 20 to generate a display rolled fingerprint image array characteristic of a display rolled fingerprint image 86. As the finger 18 is being placed down, i.e. in preview mode, the entire interim data array, characteristic of interim image 66a (which is the same as optical image 62a), is transferred to display VRAM 56 and displayed "live." In Fig. 8A, the live image is image 86a. As discussed above, when the capture mode is entered the data in interim data array representative of the contact strip 72 between the left and right edges 74, 76 of the binary contact image 70 is updated. When the finger begins to roll, a portion of the data in interim data array from Catch VRAM 52, which is representative of the strip behind the current freeze column 80b relative to the direction of finger roll, is transferred to display rolled fingerprint image array. This strip, shown in Fig. 8B as strip image 88b, extends to the far left edge of interim image 66b and is

therefore representative of areas of the platen surface that are not contacted by the finger 20. Thereafter, the portions of data from the interim data array representative of a strip of interim image 66 just adjacent to, but not overlapping with the previous freeze column 80b, 80c, respectively, and up to the leading edge 74 of the contact strip 72 are transferred from the Catch VRAM 52 to Display VRAM 56. These strips are illustrated in Figs. 7C and 7D as strip images 88c and 88d, respectively. This maintains a complete image 86c, 86d, respectively, of the developing rolling fingerprint image in the display rolled fingerprint image array in Display VRAM 56. Referring now also to Fig. 8E, when the capture is deemed complete, the portion of the interim data array representative of the forward strip 88e of the interim image 66e, from the previous freeze column 80d to the far forward edge of the interim data array is transferred to the display VRAM 56. This last update may also include data representative of areas to the far right edge of the platen 20 not contacted by the finger 18. Each update is a portion of interim data array that has been processed by the minimum function 48.

Many variations of the display method can be implemented with corresponding differences in the display quality. For example, whether to update blank areas to the right and left of the contact area, or whether to update from the output image memory or the catch memory, are options that can be traded-off for processing efficiency. Another alternative is not to display anything forward of the current freeze column 80, for example, if the processing time is needed.

After the capture is complete, the operator presses a button to either reject the print or save the print. If the print is saved, the background can be whitened out to present a cleaner image. This is

accomplished by comparing the output image with the image remaining on the platen. It is assumed that the operator has lifted the finger before pressing the save button. If a pixel value in the output image is below a corresponding value of a remanent image (i.e. the image of the platen without the finger) by a selected fraction (e.g. approximately 5%), then the pixel is considered contacted and is tagged accordingly. All pixels which are not tagged are whitened to a consistent background level. This eliminates any latent images that might be present in the background or in the voids within the print.

Note that, after each of the image memory 44, output memory 54 and display memory 56 are initialized with data representative of an initial image, there is no place in the system where the optical image signal 42 or portion of the optical image signal is actually stored. All subsequent frames of optical image signal 42 representative of optical fingerprint images from the image system 16 are processed through minimum function 48. It is only a portion of the data in each updated interim data array in image memory 44 that is used to update the output and display memories 54, 56.

In the embodiments described above, Min LUT 48 updates an interim data array in image memory 44 from the existing pixel values of interim data array and corresponding data from a new frame of optical image signal 42 input through the A/D converter 18 and Equ LUT 38. The method only uses the bottom bit of each pixel in image memory 44 to indicate contact. As the finger 20 rolls, the processor updates the output and display memories 54, 56, respectively, with a portion of the interim data array representing a forward portion of the contact strip 72 in the image memory 44. Thus, output and display rolled fingerprint image arrays are

respectively formed in output and display memories 54, 56. The rolled fingerprint image arrays are characteristic of a rolled fingerprint image.

In another embodiment, the interim data array may be developed in image memory 44 such that the accumulation of the optical image signal 42 and therefore also the interim data array is stopped behind the freeze column 80. This could be implemented with hardware (not shown), for example with a hardware register (not shown) that stores the information identifying the freeze column 80 and with controls to inhibit storage either right or left of the line, depending on the direction of rolling the finger 18. The processor 30 need only update that freeze column 80 and transfer the interim data array to the output memory 54 when capture is complete.

The function of freezing the updating of the interim image array in image memory 44 can also be implemented as part of the operation of Min LUT 48. For example, one of the address inputs to the Min LUT 48 can be allocated to selecting the data to be frozen in interim data array or to be updated by Min LUT 48. This bit can be controlled by a comparison of the image column with the freeze column 80, which is stored in a register updated by the processor 30.

The smear reduction can be improved by using a more general approach to defining the contact strip, for example determining the contact strip on a row by row basis, but this would take much more processing. The Min LUT 48 could still be used to update the interim data array in image memory 44. The freeze position could be controlled on a line by line basis by storing the freeze column 80 for each line in a memory (not shown) addressed by line number. This memory could be updated by the processor 30 for each field, during the blanking periods of the video or by using dual port techniques. The

freeze position for each line is developed from sensing the active range for several lines through the image and then providing a smoothed or interpolated position for the freeze position of the intervening lines.

While the current implementation utilizes an interlaced video input, the invention can also be implemented with a camera that provides a progressive scan, i.e., a scan which outputs only one frame, without any interlacing of lines. This would obviate the need for as much modification of the minimum function.

Since the progress of the roll is being tracked by the processor 30, it is possible to eliminate some of the button pressing by the operator. This is principally achieved by clearing the image memory 44 and restarting capture automatically under certain conditions, depending on the preferred mode of operating the system.

As an example of this method, the operator indicates he wants to save an image by pressing a save button (not shown) or a save foot switch (not shown) after the image capture is deemed complete as in the method described above. To reject the print, the finger is placed back down and rolled again. When the processor detects that the finger is in contact again, the image memory is cleared and the capture restarted. Note that this allows the preview mode to be integrated with the capture mode, provided that the operator lifts and replaces the finger prior to the capture.

The processor 30 can be configured to restart the capture when it determines that the finger 18 changes direction the first time. This corresponds well to the normal operation of placing the finger down to center it, rolling the finger back to one side, then rolling the fingerprint.

The operator assumes that he will roll all the fingers in order. If he wishes to reject a fingerprint,

he presses a button. The operation is to keep placing a finger down without rolling until it is centered, then to roll the finger to one side, and then to roll the finger for the capture. This operation can be determined from the states identified for freezing the image - placing the finger down, rolling left or rolling right, lifting the finger. An additional criterion may be placed upon the amount of roll to differentiate between placing the finger and performing a complete capture.

It will be understood by those skilled in the art of electronic fingerprint image capture that the imaging system 16 can be designed in an equivalent embodiment to provide a signal to the A/D converter 36 that indicates fingerprint ridge features by high values and fingerprint valley features by low values. The methods and devices described above would then require only small modifications to accommodate this change.

It will also be understood that although the optical image signal is described above as a data stream, the optical image signal can also be formatted as an array of pixels.

The following appendix contains C language source code for software for operating an Identix TP-600 fingerprint capture device.

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Defined functions, SUMMARY Graphic TREEs (of CALLER/CALLED flow Structure)

```
 812 FNGRCAPT.C      1 CaptSaveAct
 161 GSP_INIT.C      2 |--load_LUTTBL_to_MinSram
  79 GRABBER.C       3 |--turn_grab_on
  46 GRABBER.C       4 |--turn_grab_off
 624 FNGRCAPT.C      5 |--display_fingerprint
1014 FNGRCAPT.C      6 |  |--display_4_3v
  61 MINIO.C         7 |  |  |--mim_size
  53 MINIO.C         8 |  |  |--mim_adr
  70 MINIO.C         9 |  |  |--mim_inc
  15 MINIO.C        10 |  |  |--mim_new
  38 MINIO.C        11 |  |  |--mim_move
                    12 |  |  |  |..Bytebit
                    13 |  |..poke_breg asm
1110 FNGRCAPT.C     14 |--fill_even_pixels
  61 MINIO.C        15 |  |--mim_size ( 7 )
  53 MINIO.C        16 |  |--mim_adr ( 8 )
 282 GSP_INIT.C     17 |--copy_image_to_Dram
 111 GRABBER.C      18 |--turn_grab_on_normal
  38 MINIO.C        19 |--mim_move ( 11 )
  61 MINIO.C        20 |--mim_size ( 7 )
                    21 |..display_columns_4_3
 798 FNGRCAPT.C     22 CaptScanAct
  46 GRABBER.C      23 |--turn_grab_off ( 4 )
 758 FNGRCAPT.C     24 PrevSaveAct
  46 GRABBER.C      25 |--turn_grab_off ( 4 )
  79 GRABBER.C      26 |--turn_grab_on ( 3 )
                    27 |..OSRPend_key
 732 FNGRCAPT.C     28 PrevScanAct
  46 GRABBER.C      29 |--turn_grab_off ( 4 )
 181 GSP_INIT.C     30 |--load_LUTTBL_to_MinSram ( 2 )
 111 USERINTF.C     31 PrintTitle
                    32 |..set_colors select_font text_width text_out
  88 FNGRCAPT.C     33 VOID
                    34 |..prevscr_key_scr
 128 FNGRCAPT.C     35 captscr_key_act
 108 FNGRCAPT.C     36 captscr_key_scr
 118 FNGRCAPT.C     37 capture_t
                    38 |..prevscr_key_act
```

```
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 659 FNGRCAPT.C      39 display_camera
 514 GSP_INIT.C      40 |--load_straight_thruLUT_to_EquDram
 181 GSP_INIT.C      41 |--load_LUTTBL_to_MinDram ( 2 )
  79 GRABBER.C       42 |--turn_grab_on ( 3 )
 624 FNGRCAPT.C      43 |--display_fingerprint ( 5 )
  44 GRABBER.C       44 |--turn_grab_off ( 4 )
                     45 |..ramdac_display_cross_symbol OSOPend_key
                           ramdac_clear_cross_symbol

  74 USERINTF.C      46 display_text
                     47 |..text_out

1036 FNGRCAPT.C      48 fill_col_4_3
  61 MINIO.C         49 |--mim_size ( 7 )
  53 MINIO.C         50 |--mim_adr ( 8 )
  70 MINIO.C         51 |--mim_inc ( 9 )

 192 FNGRCAPT.C      52 image_capture

 931 FNGRCAPT.C      53 |--finger_type_check

 159 FNGRCAPT.C      54 |--my_mim_init
  15 MINIO.C         55 |  |--mim_new ( 10 )

  27 MINIO.C         56 |  |--mim_subset
  70 MINIO.C         57 |  |--mim_inc ( 9 )
  53 MINIO.C         58 |  |--mim_adr ( 8 )
  61 MINIO.C         59 |--mim_size ( 7 )

 323 GSP_INIT.C      60 |--load_equref_to_EquDram

 478 GSP_INIT.C      61 |  |--load_equLUT_to_EQUSram

 551 GSP_INIT.C      62 |  |  |--floor0
 514 GSP_INIT.C      63 |  |--load_straight_thruLUT_to_EquDram ( 40 )

 705 FNGRCAPT.C      64 |--PrevInitAct
 181 GSP_INIT.C      65 |  |--load_LUTTBL_to_MinDram ( 2 )
  79 GRABBER.C       66 |  |--turn_grab_on ( 3 )
 624 FNGRCAPT.C      67 |--display_fingerprint ( 5 )
 111 GRABBER.C       68 |--turn_grab_on_normal ( 18 )

 857 FNGRCAPT.C      69 |--fz_detect_edges

  77 MINIO.C         70 |  |--mim_fill
                     71 |  |  |..Bytefill

  45 MINIO.C         72 |  |--mim_move_c
                     73 |  |  |..Bytablt
  61 MINIO.C         74 |  |--mim_size ( 7 )
  53 MINIO.C         75 |  |--mim_adr ( 8 )

1062 FNGRCAPT.C      76 |--smooth_scan_line

 913 FNGRCAPT.C      77 |--save_columns
  61 MINIO.C         78 |  |--mim_size ( 7 )
  27 MINIO.C         79 |  |--mim_subset ( 56 )
  38 MINIO.C         80 |  |--mim_move ( 11 )
  38 MINIO.C         81 |--mim_move ( 11 )
  44 GRABBER.C       82 |--turn_grab_off ( 4 )
```

```
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  79 GRABBER.C       83 |--turn_grab_on ( 3 )
                     84 |..CaptureScreen OSOPend_key display_columns_4_3

 113 GSP_INIT.C      85 initialize_34020

 563 GSP_INIT.C      86 |--setup_graphic
                     87 |  |..set_config clear_whole_screen install_font
                              select_font get_fontinfo

  23 GRABBER.C       88 |--init_gsp_grabber
  44 GRABBER.C       89 |  |--turn_grab_off ( 4 )

 201 GSP_INIT.C      90 |--calculate_minfuncLUT_to_Dram
 551 GSP_INIT.C      91 |  |--floor0 ( 62 )

 232 GSP_INIT.C      92 |--calculate_straight_thruLUT_to_Dr

 252 GSP_INIT.C      93 |--calculate_toggingLUT_to_Dram
                     94 |..asm init_ramdac turn_illuminator_on

  85 MINIO.C         95 mim_fill_c
                     96 |..Bytefill

  98 FNGRCAPT.C      97 misfngscr_key_scr

  87 USERINTF.C      98 text_length
                     99 |..text_width

 143 GRABBER.C      100 wait_for_grab_VBLANK_on_off
```

```
/*
** Filename: fngrcapt.c
** Purpose: Routines to handle the finger image capture and user interface.
** Date:     08/03/93
** Author:   Joyce Young
** Revised:
**           12/10/93 - Ellen Yu, rewrote this routine according new spec.
** History:
**  02/25/94 Joyce Young, Added the fng_num in IMAGE_ATTR_T
**  05/10/94 Joyce Young, Moved display_camera() & display_fingerprint() here
**  06/03/94 Joyce Young, adjust the offset of ROLL/PLAIN active image in
**               GREVRAM for new board
**  06/09/94 Ellen Yu, add #define PROTOTYPE difference the hardware
**               prototype board and other new revisions.
**  11/18/94 JY, delete CAPT_ABORT case
**   4/15/95 TS, fixed up for tip desmearing
*/

/* ------------------------------ Includes ------------------------------ */
#include <gspreg.h>
#include <gsptypes.h>
#include <gspglobs.h>
#include <stdlib.h>

#include "stdtypes.h"
#include "coorddef.h"
#include "gsp_defs.h"
#include "gsp_imgs.h"
#include "imgglobs.h"
#include "mem_addr.h"
#include "mem_allc.h"
#include "mimio.h"
#include "gsp_func.h"


/* ------------------------- External Functions ------------------------*/

extern VOID load_equref_to_EquDram (image_type_t camera);
extern VOID load_LUTTBL_to_MinSram (UBYTE *src_ptr);
extern VOID load_straight_thruLUT_to_Equdram (VOID);
extern keytype_t OSOPend_key(VOID);
extern VOID setup_display_screen (char *namep);

extern VOID copy_image_to_Dram (image_type_t camera, ULONG img_store_addr,
        int ht_bytes, int wd_words);

extern VOID CaptureScreen(IMAGE_ATTR_T, scan_type_t, char *);
extern VOID Capt_CaptScr(IMAGE_ATTR_T, short);
extern VOID Capt_PrevScr(IMAGE_ATTR_T, short);
extern VOID Misfng_MisfngScr(IMAGE_ATTR_T, short);
extern VOID Misfng_PrevScr(IMAGE_ATTR_T, short);
extern VOID Prev_CaptScr(IMAGE_ATTR_T, short);
extern VOID Prev_MisfngScr(IMAGE_ATTR_T, short);
extern VOID PrevInitScr(IMAGE_ATTR_T, short);

/* ------------------------ External Variables ------------------------ */
extern image_type_t equref_camera;


 * ------------------------ Function Prototype ------------------------*/
```

```
VOID my_mim_init(UBYTE *store_addr);
capture_t image_capture (image_type_t camera, scan_type_t fng_num,
      char *namep, ULONG img_store_addr);
VOID display_camera (image_type_t camera);
VOID display_columns_6_3(MIM *source,MIM *disp,int x,int w);
VOID display_6_3v(MIM *source,MIM *dest);
VOID fill_col_6_3(MIM *dest, int col, int value);
VOID save_columns(MIM *source,MIM *dest,int start, int stop);
VOID display_fingerprint (image_type_t camera, UBYTE *src_start_ptr,
      UBYTE *dst_start_ptr);
VOID fill_even_pixels(MIM *dest,int value);
capture_t CaptScanAct( IMAGE_ATTR_T image );
capture_t CaptSaveAct( IMAGE_ATTR_T image );
capture_t PrevSaveAct( IMAGE_ATTR_T image );
capture_t PrevScanAct( IMAGE_ATTR_T image );
capture_t PrevInitAct( IMAGE_ATTR_T image );

typedef enum
{
      NO_DIR,
      RIGHT_DIR,
      LEFT_DIR
} ROLL_DIRECTION;

int finger_type_check(scan_type_t fngnum,image_type_t *camera,
      HAND_TYPE *hand, ROLL_DIRECTION *desmmer);

VOID (*prevscr_key_scr[])(IMAGE_ATTR_T, short) =
{
      NULL,
      Prev_CaptScr,
      NULL,
      Prev_MisfngScr,
      NULL,
      NULL
};

VOID (*misfngscr_key_scr[])(IMAGE_ATTR_T, short) =
{
      NULL,
      Misfng_PrevScr,
      NULL,
      Misfng_MisfngScr,
      NULL,
      NULL
};

VOID (*captscr_key_scr[])(IMAGE_ATTR_T, short) =
{
      NULL,
      Capt_PrevScr,
      NULL,
      Capt_CaptScr,
      NULL,
      NULL
};

capture_t (*prevscr_key_act[])(IMAGE_ATTR_T) =
{
      NULL,
```

```
        PrevScanAct,
        NULL,
        PrevSaveAct,
        NULL,
        NULL
};

capture_t (*captscr_key_act[])(IMAGE_ATTR_T) =
{
        NULL,
        CaptScanAct,
        NULL,
        CaptSaveAct,
        NULL,
        NULL
};

/* structures for defined arrays in memory */

MIM gvram;
MIM gvram_reduced;
MIM gminram;
MIM disp_window;
MIM plain_disp_window;
MIM data_store;
MIM central_rows;
MIM detect_row;
MIM check_row;

UBYTE detect_buf[1024];

/* -----------------------------------------------------------------*/
/*
** Func name: VOID my_mim_init()
** Purpose:   initialize the memory areas for the grabber vram, the display
**            and the roll storage area.
** Returns:   None
*/
VOID my_mim_init(UBYTE *store_addr)
{
        mim_new(&gvram,((UBYTE *)GRB_VRAM_END)-GRBVRAM_WD_BYTES*26+100,
                -GRBVRAM_WD_BYTES,ROLL_WD_PIXELS,ROLL_HT_PIXELS);

        mim_new(&gvram_reduced,((UBYTE *)GRB_VRAM_END)-GRBVRAM_WD_BYTES*27+76,
                -GRBVRAM_WD_BYTES,ROLL_WD_PIXELS*3/4,ROLL_HT_PIXELS);

        mim_new(&gminram,((UBYTE *)MIN_DRAM_END)-MINDRAM_WD_BYTES*26+100,
                -MINDRAM_WD_BYTES,ROLL_WD_PIXELS,ROLL_HT_PIXELS);

        mim_new(&disp_window,((UBYTE *)DPY_VRAM_BASE)+DPYVRAM_WD_BYTES*4+12,
                DPYVRAM_WD_BYTES,720,720);

        mim_subset(&disp_window,&plain_disp_window,0,732-IMG_PLAIN_H,
                IMG_PLAIN_W-12,IMG_PLAIN_H);

        mim_new(&data_store,store_addr,ROLL_WD_PIXELS,
                ROLL_WD_PIXELS,ROLL_HT_PIXELS);

        mim_new(&central_rows,mim_adr(&gvram,0,400),5*mim_inc(&gvram),
                ROLL_WD_PIXELS,25);
```

```
        mla_new(&detect_row,detect_buf,0,ROLL_WD_PIXELS,1);
}

/* ------------------------------------------------------------------*/
/*
** Func name: VOID my_mla_init()
** Purpose:   Image capture process from the given camera
**            (Roll = 0, Plain = 1).
** Returns:   type in the typedef capture_t
*/
capture_t image_capture (image_type_t camera, scan_type_t fng_num,
        char *namep, ULONG img_store_addr)
{
        IMAGE_ATTR_T  image;
        keytype_t  key_pressed;
        capture_t  ret;
        UBYTE *src_start_ptr, *dst_start_ptr;

        int far_r_edge,far_l_edge;
        int r_edge,l_edge;
        int s_w,s_h;
        int new_scan_line,scan_line;

        image_type_t fng_camera;
        HAND_TYPE hand;
        ROLL_DIRECTION capt_dir;

        /*
        ** parameters controlling the states of the rolling
        */
        int edge_tol = 20;
        int active_threshold = 150;
        int enough = 10;
        int extra = 25;
        int max_columns_in_step = 50;
        enum
        {
                BLANK,
                PRESS,
                ROLL_RIGHT,
                ROLL_LEFT,
                LIFT,
                GONE
        } capt_state;

        /*
        ** check what camera to use    and required direction
        */

        if ((finger_type_check(fng_num, &fng_camera, &hand, &capt_dir)
           || fng_camera != camera)
        return(CAPT_WRONG_TYPE);

        my_mla_init((UBYTE *)img_store_addr);

        mla_size(&gvram,&s_w,&s_h);

        /*
        ** image offset should be matched in image_capture() and display_camera()
```

```
** these pointers are only used for the plain
*/
src_start_ptr = (UBYTE *)GRB_VRAM_END - SCR_W * 24 + 79;
dst_start_ptr = (UBYTE *)DPY_VRAM_BASE + SCR_W * 6 + 12;

if( camera == PLAIN )
{
        src_start_ptr += 20;
        dst_start_ptr += SCR_W * (732 - IMG_PLAIN_H);
}

/*
** Get attributes of image and put into structure( IMAGE_ATTR_T )
*/
image.camera = camera;
image.hand = hand;
image.store_addr = img_store_addr;
image.src_addr = src_start_ptr;
image.dst_addr = dst_start_ptr;
image.fng_num = fng_num;

CaptureScreen( image, fng_num, namep );

/*
** Load the Equ data that were created during calibration for ROLL
** or PLAIN from the Dram to EquDram, when the current calling camera
** is different from the previous camera,
*/
if ( equref_camera != camera )
        load_equref_to_EquDram (camera);

/*
** Wait for key pressed
*/
key_pressed = TYPE_NO_RESPONSE;
while( key_pressed != TYPE_SAVE_KEY )
{
        /*
        ** 1. Copy the straight thru function from Dram to MinSram
        ** 2. Turn grabber on
        */
        PrevInitAct( image );

        /*
        ** Preview operation
        */
        key_pressed = TYPE_NO_RESPONSE;
        while( key_pressed != TYPE_SCAN_KEY )
        {
                /*
                **  Display image by copy fingerprint from grabber VRAM to
                **  display VRAM.
                */
                display_fingerprint (camera, src_start_ptr, dst_start_ptr);

                key_pressed = OSQPend_key();

                if( (*prevscr_key_scr[key_pressed]) != NULL )
                      (* prevscr_key_scr[key_pressed])( image, DRAW );
```

```
        if( (*prevscr_key_act[key_pressed]) != NULL )
        {
                ret = (*prevscr_key_act[key_pressed])( image );
                if( ret == CAPT_MISSING )(
                        return( ret );
                }
        }
    }   /* end of while */

    /*
    ** Capture operation
    */
    if (capt_dir == RIGHT_DIR || capt_dir == LEFT_DIR)
    {
        turn_grab_on_normal (image.camera, 1);

        capt_state=BLANK;

        key_pressed = TYPE_NO_RESPONSE;
        while( key_pressed != TYPE_SCAN_KEY && key_pressed != TYPE_SAVE_KEY)
        {
                switch (capt_state)
                {
                        case BLANK:
                                /*
                                **      wait for the finger to come down
                                **      display the active area when it is sensed
                                */
                                if (fz_detect_edges(&central_rows,edge_tol,active_threshold,
                                        &r_edge,&l_edge))
                                {
                                        capt_state=PRESS;
                                        far_r_edge=r_edge;
                                        far_l_edge=l_edge;
                                }
                                break;

                        case PRESS:
                                /*
                                **      display the active area
                                **  until both edges begin to roll in the correct direction
                                **  then save the back side of the active area
                                **  Allow the roll to go in either direction
                                */
                                if (fz_detect_edges(&central_rows,edge_tol,active_threshold,
                                        &r_edge,&l_edge))
                                {
                                        if (l_edge > far_l_edge+enough)
                                        {
                                                scan_line = smooth_scan_line(-1,r_edge,l_edge,capt_dir,
                                                        max_columns_in_step);
                                                /*
                                                **  Save the left side of the active area
                                                **  Don't update the display
                                                */
                                                save_columns(&gvram,&data_store,0,scan_line);
                                                capt_state=ROLL_RIGHT;
                                                break;
                                        }
```

```
                if (r_edge < far_r_edge+enough)
                {
                        scan_line = smooth_scan_line(-1,r_edge,l_edge,capt_dir,
                                max_columns_in_step);
                        /*
                        ** Save the left side of the active area
                        ** Don't update the display
                        */
                        save_columns(&gvram,&data_store,scan_line,s_w);
                        capt_state=ROLL_LEFT;
                        break;
                }
                /*
                ** While not rolling just display the active columns
                **
                */
                if (l_edge-extra >= 0)
                {
                        if (r_edge+extra < s_w)
                                display_columns_4_3(&gvram,&disp_window,l_edge-extra,
                                        r_edge-l_edge+2*extra);
                        else
                                display_columns_4_3(&gvram,&disp_window,l_edge-extra,
                                        s_w-l_edge+extra);
                }
                else if (r_edge+extra < s_w)
                        display_columns_4_3(&gvram,&disp_window,0,r_edge+extra);
                else
                        display_columns_4_3(&gvram,&disp_window,0,s_w);


                if (l_edge < far_l_edge)
                        far_l_edge = l_edge;
                if (r_edge > far_r_edge)
                        far_r_edge=r_edge;
        }
        else
        {
                mim_move(&gvram,&data_store);
                display_columns_4_3(&data_store,&disp_window,0,s_w);
                capt_state=LIFT;
        }
        break;

case ROLL_RIGHT:
        /*
        ** save the area incremented by the scan line
        ** display right side of the active area
        **      until the right edge stops
        ** then save the right side of the active area
        */
        if (fz_detect_edges(&central_rows,edge_tol,active_threshold,
                &r_edge,&l_edge))
        {
                new_scan_line = smooth_scan_line(scan_line,r_edge,l_edge,RIGHT_DIR,30);
                if (new_scan_line > scan_line)
                {
                        save_columns(&gvram,&data_store,scan_line,new_scan_line);
                        scan_line=new_scan_line;
                        if (r_edge+extra < s_w)
```

```
                    display_columns_4_3(&gvram,&disp_window,scan_line,
                            r_edge+extra-scan_line);
                else
                    display_columns_4_3(&gvram,&disp_window,scan_line,
                            s_w-scan_line);
            /* display the scan line for debug
                fill_col_4_3(&disp_window,scan_line,0);
            */
            }

            if (r_edge < far_r_edge - enough)
            {
                save_columns(&gvram,&data_store,scan_line,s_w);
                display_columns_4_3(&data_store,&disp_window,scan_line,
                        s_w-scan_line);
                capt_state=LIFT;
            }
            if (l_edge < far_l_edge)
                far_l_edge = l_edge;
            if (r_edge > far_r_edge)
                far_r_edge=r_edge;

        }
        else
        {
            save_columns(&gvram,&data_store,scan_line,s_w);
            display_columns_4_3(&data_store,&disp_window,scan_line,s_w-scan_line);
            capt_state=LIFT;
        }

        break;

    case ROLL_LEFT:
        /*
        **  save the area incremented by the scan line
        **  display left side of the active area
        **      until the left edge stops
        **  then save the left side of the active area
        */
        if (fz_detect_edges(&central_rows,edge_tol,active_threshold,
                &r_edge,&l_edge))
        {
            new_scan_line = smooth_scan_line(scan_line,r_edge,l_edge,LEFT_DIR,30);
            if (new_scan_line < scan_line)
            {
                save_columns(&gvram,&data_store,new_scan_line,scan_line);
                scan_line=new_scan_line;
                if (l_edge-extra >= 0)
                    display_columns_4_3(&gvram,&disp_window,l_edge-extra,
                            scan_line-l_edge+extra);
                else
                    display_columns_4_3(&gvram,&disp_window,0,scan_line);
            /* display the scan line for debug
                fill_col_4_3(&disp_window,scan_line,0);
            */
            }
            if (l_edge > far_l_edge + enough)
            {
                save_columns(&gvram,&data_store,0,scan_line);
                display_columns_4_3(&data_store,&disp_window,0,scan_line);
```

```
    turn_illuminator_on ();
    ptr = (ULONG *)PC_PARAMETERS;

    rollequ_exists = *ptr++;
    plainequ_exists = *ptr++;
    /* this is where version 1.3 loader puts it */
        palmequ_exists = *ptr++;
        palmwrp_exists = *ptr++;

    para_exists = *ptr++;

    if ( para_exists )
        {
         if (*ptr != 255) recursive_factor = *ptr;
         ptr++;
         if (*ptr != 255) fngr_desired_equ_value = *ptr;
         ptr++;
         if (*ptr != 255) changing_threshold = *ptr;
         ptr++;
         if (*ptr != 255) too_dark_value = *ptr;
         ptr++;
         if (*ptr != 255) roll_offset = *ptr;
         ptr++;
         if (*ptr != 255) plain_offset = *ptr;
         ptr++;
         if (*ptr != 255) palm_offset = *ptr;
         ptr++;
         if (*ptr != 255) palm_desired_equ_value = *ptr;
         ptr++;
         }

        /* this is where version 1.4 and beyond loader keeps it
    palmequ_exists = *ptr++;
        palmwrp_exists = *ptr++;
        */

#ifndef PALM_SCANNER
    init_gsp_grabber ();

    calculate_minfuncLUT_to_Dram ();
    calculate_straight_thruLUT_to_Dram ();
    calculate_taggingLUT_to_Dram ();
#else
    /*
    ** Turn off grabber
    */
    *(UBYTE *)GRABBER_CTRLO_BASE = 0x0;
    *(UBYTE *)GRABBER_CTRLO_BASE = 0x0;

    load_straight_thruLUT_to_MinSram();
#endif
} /* initialize_34020 */

#ifndef PALM_SCANNER

/* -------------------------------------------------------------------*/
/*
** copy the LUTTSL from the given source address (in Dram by BYTE pointer)
** to MinSram (by LONG pointer)
*/
```

```
image_type_t equref_camera = NON_CAMERA;  /* which camera equ in EquDram */
int rollequ_exists = 0;          /* 1=ROLL equ exists */
int plainequ_exists = 0;         /* 1=PLAIN equ exists */
int palmequ_exists = 0;          /* 1=PALM equ exists */
int palmwrp_exists = 0;          /* 1=PALM dewarping exists */

/* -------------------- Local Variable definition ---------------------*/
/* this sets up the defaults if no parameter file exists */

static int para_exists = 0;             /* 1=image para file exists */
static ULONG recursive_factor = 66;/* sensitivity of capture to field rate */
static ULONG fngr_desired_equ_value = 252;/*value of blank platen equalized*/
static ULONG desired_equ_value = 252;  /* value of blank platen equalized */
static ULONG changing_threshold = 13;  /* percentage change of final to post
                  scan image, if not exceeded will white/tag out the data */
static ULONG too_dark_value = 5;        /* to remove A/D offset */
static ULONG roll_offset = 10;   /* ROLL peak histogram value */
static ULONG plain_offset = 10;  /* PLAIN peak histogram value */
static ULONG palm_offset = 10;   /* PALM peak histogram value */
static ULONG palm_desired_equ_value = 252;/*value of blank platen equalized*/
static ULONG detect_level = 150;  /* detection level for active area */

/* -------------------------- External functions  --------------------*/
extern VOID init_ramdac (VOID);
extern VOID init_gsp_grabber (VOID);
extern VOID send_command_to_BIC (UBYTE command_to_send);
extern VOID turn_illuminator_on (VOID);


/* ------------------------- Function Prototypes ----------------------*/

VOID copy_image_to_Dram (image_type_t camera, ULONG img_store_addr,
     int ht_bytes, int wd_words);
VOID initialize_34020 (VOID);
VOID load_equref_to_EquDram (image_type_t camera);
VOID load_LUTTBL_to_MinSram (UBYTE *src_ptr);
VOID load_straight_thruLUT_to_EquSram (VOID);
VOID setup_graphic (VOID);

static VOID calculate_minfuncLUT_to_Dram (VOID);
static VOID calculate_straight_thruLUT_to_Dram (VOID);
static VOID calculate_taggingLUT_to_Dram (VOID);
static ULONG floor0 (ULONG a, ULONG b);
static VOID load_equLUT_to_EQUSram (ULONG offset, ULONG dark_offset, ULONG desired);
static VOID load_straight_thruLUT_to_MinSram (VOID);


/* ------------------------------------------------------------------*/
/*
** Initialize the Ramdac, the GSP registers, setup the graphic functions
** and create all LUTs.
*/
VOID initialize_34020 (VOID)
{
    volatile ULONG *ptr;

    *((USHORT *)DPYCTL) = 0;
    asm ("        NWAIT         ");
    init_ramdac ();
    setup_graphic ();
```

```
/*
** Filename: gsp_init.c
** Purpose:  GSP Initialization.
** Date:     08/10/93
** Author:   Joyce Young
** History:
**  02/18/94 Joyce Young, modify the offset of PLAIN active image
**  05/05/94 Joyce Young, if image parameter is 255, set default value
**  06/03/94 Joyce Young, adjust the offset of ROLL/PLAIN active image in
**           MINDRAM for new board
**  06/28/94 Joyce Young, turn_illuminator_on in initialize_34020, otherwise,
**           turning illuminator off during calibration and then receiving
**           ABORT command will cause the illuminator off after ABORT done
**  07/14/94 Joyce Young, change default roll_peak_illum_level = 10 &
**           plain_peak_illum_level = 10
**  08/11/94 TS, fix up offsets so that they add to the offsets calculated
**         from the dark level histogram instead of replacing it.
**  09/05/94 TS, change tagging so that a 0 change_threshold value causes
**           everything to be tagged.
**  09/22/94 JY, move setup of talon_font(CORPUS29) & talon_font(CORPUS49)
**           from PrintTitle() to setup_graphic(), otherwise, if calling
**           PrintTitle() several times, will mess up the talon_font table
**  09/29/94 TS, fixed error in Equ Sram initialization - needed to subtract
**           out offset after scaling. Cause severe clipping at white.
**  01/18/95 JY, read existing of palm.equ from PC_PARAMETERS
**  01/20/95 JY, delete unnecessary include files
**  01/23/95 JY, load palm equ to EQU_DRAM if file exists
*/

/* -------------------------------- Includes ------------------------------ */
#include <gspreg.h>
#include <gsptypes.h>
#include <gspglobs.h>

#include "stdtypes.h"
#include "gsp_font.h"
#include "img_defs.h"
#include "mem_addr.h"
#include "mem_allc.h"
#ifndef PALM_SCANNER
#include "gsp_imgs.h"
#endif

/* ------------------- Extern Variable definition --------------------*/

/*
** variables for the graphic
*/
extern FONT corpus29, corpus49;

/* ------------------- Global Variable definition --------------------*/

FONTINFO fontinfo;
short smlfont_id, bigfont_id;
short smlfont_charhigh, bigfont_charhigh;
short smlfont_charwide, bigfont_charwide;

/*
** variables for the image processing
*/
```

```
            else
                    new_scan_line = old_scan_line;
        }
        else if (roll_dir == LEFT_DIR)
        {
                new_median = (scan_split*left + (8-scan_split)*right) /8;
                if (new_median < old_scan_line)
                {
                        new_scan_line = (factor*new_median + (8-factor)*old_scan_line + 4)/8;
                        if (new_scan_line < old_scan_line - max_columns)
                                new_scan_line = old_scan_line - max_columns;
                }
                else new_scan_line = old_scan_line;
        }
        else new_scan_line = new_median;

        return(new_scan_line);

} /* int smooth_scan_line */

/*********************************************************************
**
** replace any untagged pixels (even values) in the destination area
** with value
**
*/
void fill_even_pixels(MIM *dest,int value)
{
        register UBYTE *pp;
        register int vv,jj;

        int w,h,ii;

        vv = value;
        mim_size(dest,&w,&h);

        for (ii=0; ii<h; ii++)
        {
                pp = mim_adr(dest,0,ii);
                jj =w;
                do
                {
                        if (!(*pp & 1)) *pp = vv;
                        pp++;
                }
                while (--jj);
        }
}
/* ---------------------------------------------------------------*/
/* end of fngrcapt.c */
```

```
                mim_new(&src_rows,mim_adr(source,0,ii),4*mim_inc(source),w,h/4);
                mim_new(&dst_rows,mim_adr(dest,0,ii),3*mim_inc(dest),0,0);
                mim_move(&src_rows,&dst_rows);
        }
} /* display_4_3v */

/* ----------------------------------------------------------------*/
/*
** Func name: VOID fill_col_4_3()
** Purpose:   fill a column in a range reduced by 4/3
** Returns:   None
*/
VOID fill_col_4_3(MIM *dest, int col, int value)
{
        register int ii,k,d_i;
        register unsigned char *d;
        int w,h;

        k = value;
        mim_size(dest,&w,&h);
        d = mim_adr(dest,col*3/4,0);
        d_i = mim_inc(dest);

        ii=h;
        do
        {
        *d=k;
        d+=d_i;
        } while (--ii);

} /* fill_col_4_3 */

/* ----------------------------------------------------------------*/
/*
** Func name: int smooth_scan_line()
** Purpose:   even out the scan line steps and limit them to a maximum size.
** Returns:   new scan line
*/
int smooth_scan_line(int old_scan_line, int right, int left,
    ROLL_DIRECTION roll_dir, int max_columns)
{
        int new_median, new_scan_line;
        int scan_split = 5;
        int factor = 4;

        if (old_scan_line < 0 )
        {
                new_median = (right + left) / 2;
                return (new_median);
        }

        if (roll_dir == RIGHT_DIR)
        {
                new_median = (scan_split*right + (8-scan_split)*left) /8;
                if (new_median > old_scan_line)
                {
                        new_scan_line = (factor*new_median + (8-factor)*old_scan_line + 4)/8;
                        if (new_scan_line > old_scan_line + max_columns)
                                new_scan_line = old_scan_line + max_columns;
                }
```

```
        case STYPE_ROLL_LEFT_LITTLE:
                *camera = ROLL;
                *hand = LEFT;
                *desmear = LEFT_DIR;
                break;

        case STYPE_PLAIN_TWO_THUMBS:
                *camera = ROLL;
                *hand = RIGHT;
                *desmear = NO_DIR;
                return(1);
                break;

        case STYPE_PLAIN_RIGHT4:
                *camera = PLAIN;
                *hand = RIGHT;
                *desmear = NO_DIR;
                break;

        case STYPE_PLAIN_LEFT4:
                *camera = PLAIN;
                *hand = LEFT;
                *desmear = NO_DIR;
                break;

        case STYPE_PLAIN_RIGHT_THUMB:
                *camera = ROLL;
                *hand = RIGHT;
                *desmear = NO_DIR;
                break;

        case STYPE_PLAIN_LEFT_THUMB:
                *camera = ROLL;
                *hand = LEFT;
                *desmear = NO_DIR;
                break;

        default:
                return( 1 );
    }
    return (0);
} /* finger_type_check */

/* ---------------------------------------------------------------------*/
/*
** Func name: VOID display_4_3v()
** Purpose:   display the whole fingerprint with a 4:3 reduction in the
**            vertical direction, drop every fourth line
** Returns:   None
*/
VOID display_4_3v(MIM *source,MIM *dest)
{
        MIM src_rows,dst_rows;
        int w,h,s_i,ii;

        mim_size(source,&w,&h);


        for (ii=0; ii<3; ii++)
        {
```

```
                return(0);
} /* fz_detect_edges */

/* ---------------------------------------------------------------*/
/*
** Func name: save_columns()
** Purpose:   block transfer selected columns of the source to the image
** Return:    None
*/
VOID save_columns(MIM *src,MIM *dest,int start, int stop)
{
        int s_w,s_h;
        MIM src_cols,dest_cols;

        mim_size(src,&s_w,&s_h);
        mim_subset(src,&src_cols,start,0,stop-start,s_h);
        mim_subset(dest,&dest_cols,start,0,0,0);
        mim_move(&src_cols,&dest_cols);
} /* save_columns */

/* ---------------------------------------------------------------*/
/*
** Func name: finger_type_check()
** Purpose:   decode the finger type, camera, whether to desmear and validity
** Returns:   0 - if no error
**            1 - otherwise
*/
int finger_type_check(scan_type_t fng_num,image_type_t *camera,
        HAND_TYPE *hand, ROLL_DIRECTION *desmear)
{
        /*
        ** decode the finger type, camera, whether to desmear and validity
        ** return (0) if no error
        */
        switch ( fng_num )
        {
                case STYPE_ROLL_RIGHT_THUMB:
                        *camera = ROLL;
                        *hand = RIGHT;
                        *desmear = LEFT_DIR;
                        break;

                case STYPE_ROLL_RIGHT_INDEX:
                case STYPE_ROLL_RIGHT_MIDDLE:
                case STYPE_ROLL_RIGHT_RING:
                case STYPE_ROLL_RIGHT_LITTLE:
                        *camera = ROLL;
                        *hand = RIGHT;
                        *desmear = RIGHT_DIR;
                        break;

                case STYPE_ROLL_LEFT_THUMB:
                        *camera = ROLL;
                        *hand = LEFT;
                        *desmear = RIGHT_DIR;
                        break;

                case STYPE_ROLL_LEFT_INDEX:
                case STYPE_ROLL_LEFT_MIDDLE:
                case STYPE_ROLL_LEFT_RING:
```

```
        return( CAPT_WRONG_TYPE );

        return( CAPT_SAVEING );
} /* CaptSaveAct */

/* -- ----------------------------------------------------------------*/
**
** func name: int fz_detect_edges()
** Purpose:   Determine the right and left edges of the contact strip of
**            the fingerprint
** Returns:   0 - if there is no contact
**            1 - otherwise
*/
int fz_detect_edges(MIM *row, int edge_count, int threshold,
        int *right_edge, int *left_edge)
{
        int width,height,ii,sum;
        unsigned char *lp,*rp;

        /*
        **      Get the center rows from the image
        **  Or together all the tag bits
        */
        mim_fill(&detect_row, 0);
        mim_move_c(row,&detect_row,0x200c);
        mim_size(row, &width, &height);

        lp = mim_adr(&detect_row,0,0);
        rp = lp+width-1;

        /* find the left edge by adding up and the right edge by adding down */
        sum = 0;
        for (ii=0; ii<width; ii++)
        {
                if (*lp++ & 1) {
                        sum++;
                        if (sum >= edge_count)
                                break;
                }
        }
        *left_edge=ii;

        sum = 0;
        for (ii=width-1; ii>=0; ii--)
        {
                if (*rp-- & 1) {
                        sum++;
                        if (sum >= edge_count)
                                break;
                }
        }
        *right_edge=ii;

        /*
        **      there is contact if the right edge is farther right than the left
        **      edge
        */
        if (*right_edge > *left_edge)
                return(1);
        else
```

```
        */
        if( key_pressed == TYPE_SCAN_KEY )
                turn_grab_on (image.camera, 1);

        return( response_misfng(key_pressed) );
} /* PrevSaveAct */

/* --------------------------------------------------------------------*/
/*
** Func name: CaptScanAct()
** Purpose:   Actions when SCAN key pressed in capture screen.
** Returns:   CAPT_NO_RESPONSE
** History:   01-31-94 Joyce Young: Add return value
*/
capture_t CaptScanAct( IMAGE_ATTR_T image )
{
        /*--- Turn grabber off ---*/
        turn_grab_off (image.camera);
        return (CAPT_NO_RESPONSE);
}

/* --------------------------------------------------------------------*/
/*
** Func name: CaptSaveAct()
** Purpose:   Actions when SAVE key pressed in capture screen.
** Returns:   CAPT_SAVEING/CAPT_WRONG_TYPE
** History:   02-18-94 Joyce Young: Pass camera in copy_image_to_Dram ()
*/
capture_t CaptSaveAct( IMAGE_ATTR_T image )
{
        int  wd_words, ht_bytes, w, h;

        /*
        **      grabber should already be off
        */

        if (image.camera == PLAIN)
        {
        /*--- Tag the images for changes from the remainder image ---*/
        load_LUTTBL_to_MinSram ((UBYTE *)FNGR_TAGGING_LUTTBL);
        turn_grab_on (image.camera, 1);
        turn_grab_off (image.camera);
        display_fingerprint (image.camera, image.src_addr, image.dst_addr);
                fill_even_pixels(&plain_disp_window,254);
                /*--- Download image to the GSP DRAM ---*/
                wd_words = PLAIN_WD_WORDS;
                ht_bytes = PLAIN_HT_BYTES;
        copy_image_to_Dram (image.camera, image.store_addr, ht_bytes, wd_words);
        }
        else if (image.camera == ROLL)
        {
                load_LUTTBL_to_MinSram ((UBYTE *)FNGR_TAGGING_LUTTBL);
                turn_grab_on_normal(image.camera,1);
                turn_grab_off(image.camera);
                mim_move(&gminram,&data_store);
                mim_size(&data_store,&w,&h);
                display_columns_4_3(&data_store,&disp_window,0,w);
                fill_even_pixels(&disp_window,254);
        }
        else
```

```
/* ----------------------------------------------------------------*/
/*
** Func name: PrevScanAct()
** Purpose:   Actions when SCAN key pressed in preview screen.
** Returns:   CAPT_NO_RESPONSE/CAPT_WRONG_TYPE, no captured images or
**            wrong camera type.
*/
capture_t PrevScanAct( IMAGE_ATTR_T image )
{
        /*--- Turn grabber off ---*/
        turn_grab_off( image.camera );

        /*
        ** Load minfunc from Dram to MinSram
        */
#if IMG_DEBUG
        load_straight_thruLUT_to_EquSram ();
        load_LUTTBL_to_MinSram ((UBYTE *)STRAIGHT_THRU_LUTTBL);
#else
        load_LUTTBL_to_MinSram ((UBYTE *)MINFUNC_LUTTBL);
#endif

   return( CAPT_NO_RESPONSE );
} /* PrevScanAct */

/* ----------------------------------------------------------------*/
/*
** Func name: PrevSaveAct()
** Purpose:   Actions when SAVE key pressed in preview screen.
** Returns:   CAPT_NO_RESPONSE/CAPT_MISSFNG, no captured images or missing
**            finger
** History:   01-31-96 Joyce Young: Turn on the grabber if SCAN key pressed
*/
capture_t PrevSaveAct( IMAGE_ATTR_T image )
{
        keytype_t key_pressed;
        capture_t response_misfng[] =
        {
                CAPT_NO_RESPONSE,
                CAPT_NO_RESPONSE,
                CAPT_NO_RESPONSE,
                CAPT_MISSFNG,
                CAPT_MISSFNG,
        };

        /*--- Turn grabber off ---*/
        turn_grab_off( image.camera );

        key_pressed = TYPE_NO_RESPONSE;
        while( key_pressed != TYPE_SCAN_KEY && key_pressed != TYPE_SAVE_KEY )
                key_pressed = OSQPend_key();

        if( (*misfngscr_key_scr[key_pressed]) != NULL )
                (* misfngscr_key_scr[key_pressed])( image, DRAW );

        /*
        ** SCAN key will go to preview screen, as we turn off the grabber above,
        ** so the grabber needs to turn on here, otherwise, the finger image will
        ** not show on the preview screen
```

```
        if( camera == ROLL )
                ramdac_display_cross_symbol();

        src_start_ptr = (UBYTE *)GRB_VRAM_END;
        src_start_ptr -= SCR_W * 30 - 79;
        dst_start_ptr = (UBYTE *)DPY_VRAM_BASE;
        dst_start_ptr += SCR_W * 4 + 12;

        if ( camera == PLAIN )
        {
                src_start_ptr += 20;
                dst_start_ptr += SCR_W * (732 - IMG_PLAIN_H);
        }

        load_straight_thruLUT_to_EquSram ();
        load_LUTTBL_to_MinSram ((UBYTE *)STRAIGHT_THRU_LUTTBL);
        turn_grab_on (camera, 1);

        for (;;)
        {
                display_fingerprint (camera, src_start_ptr, dst_start_ptr);

                switch ( key_type = OSQPend_key () )
                {
                        case TYPE_SCAN_KEY:
                        case TYPE_SAVE_KEY:
                        case TYPE_ABORT:
                                turn_grab_off (camera);
                                if( camera == ROLL )
                                        ramdac_clear_cross_symbol();
                                return;
                }
        }
} /* display_camera */

/* ------------------------------------------------------------------*/
/*
** Func name: PrevInitAct()
** Purpose:   Actions when enter a preview screen.
** Returns:   CAPT_NO_RESPONSE, no captured images
*/
capture_t PrevInitAct( IMAGE_ATTR_T image )
{
        /*
        ** Load straight thru LUT from Dram to MinSram
        */
#if IMG_DEBUG
        load_straight_thruLUT_MEM_to_EquSram ();
#else
        load_LUTTBL_to_MinSram ((UBYTE *)STRAIGHT_THRU_LUTTBL);
#endif

        /*
        ** Turn grabber on 2 frame, otherwise, the second finger image will
        ** display garbage lines if using multiple finger buffers
        */
        turn_grab_on (image.camera, 2);

   return( CAPT_NO_RESPONSE );
}  /* PrevInitAct */
```

```
                                if( ret == CAPT_SAVEING )
                                {
                                        return( ret );
                                }
                        }
                }  /* end of while */
        }       /* end of if */

    }  /* end of while */
} /* image_capture */

/* ............................................................*/
/*
** Func name: VOID display_fingerprint()
** Purpose:   Draw the fingerprint in reduced form in display window.
** The fingerprint thru the T8's camera is stored upside-down in the GVRAM.
** the horizontal reduction is done in hardware
** the vertical reduction is done by dropping 1 of 4 lines in the roll
** and 1 of 2 lines in the plain.
*/
VOID display_fingerprint (image_type_t camera, USYTE *src_start_ptr,
        USYTE *dst_start_ptr)
{
        USYTE *src_ptr, *dst_ptr;
        int ii;
        if ( camera == ROLL )
        {

                /* set up 4/3 reduction */
                display_4_3v(&gvram_reduced,&disp_window);

        }
        else
        {
                /*
                ** Only display every other lines;
                ** so increment the source array 2 lines, dest. array 1 line
                ** The first display line is in the middle of the screen.
                */
                poke_breg (SADDR, src_start_ptr);       /* B0: starting addr of source array */
                poke_breg (DADDR, dst_start_ptr);       /* B2: starting addr of dest.  array */
                poke_breg (SPTCH, PLAIN_GRBVRAM_PITCH); /* B1: the pitch of source array */
                poke_breg (DPTCH, PLAIN_DPYVRAM_PITCH); /* B3: the pitch of dest. array */
                poke_breg (DYDX,  PLAIN_DYDX_VAL);      /* B7: DX: array width, DY: array height */
                asm ("        PIXBLT L, L  ");
        }
} /* display_fingerprint */

/* ............................................................*/
/*
** Func name: VOID display_camera()
** Purpose:   Display the Roll or Plain image from the given camera
**            (Roll or Plain) by using straight_thru function
** Returns:   None
*/
VOID display_camera (image_type_t camera)
{
        keytype_t  key_type;
        USYTE *src_start_ptr, *dst_start_ptr;
```

```
                                mlm_move(&gvram,&data_store);
                                break;

                        case ROLL_RIGHT:
                                save_columns(&gvram,&data_store,scan_line,s_w);
                                break;

                        case ROLL_LEFT:
                                save_columns(&gvram,&data_store,0,scan_line);
                                break;
                }
                turn_grab_off(camera);
                mlm_move(&data_store,&gminram);

        }

        if( (*captscr_key_scr[key_pressed]) != NULL )
                (*captscr_key_scr[key_pressed])( image, DRAW );

        if( (*captscr_key_act[key_pressed]) != NULL )
        {
                ret = (*captscr_key_act[key_pressed])( image );
                if( ret == CAPT_SAVEING )
                {
                        return( ret );
                }
        }
    }   /* end of while */
}

else if ((camera == ROLL && capt_dir == NO_DIR) || camera == PLAIN)
{

    turn_grab_on (image.camera, 1);

    key_pressed = TYPE_NO_RESPONSE;
    while( key_pressed != TYPE_SCAN_KEY && key_pressed != TYPE_SAVE_KEY)
    {
        /*
        **  Display image by copy fingerprint from grabber VRAM to
        **  display VRAM.
        */
display_fingerprint (camera, src_start_ptr, dst_start_ptr);

        key_pressed = OSQPend_key();

        /*
        **      turn off the grabber when the save key is pressed
        */
        if(key_pressed == TYPE_SAVE_KEY)
        {
                turn_grab_off(camera);
        }

        if( (*captscr_key_scr[key_pressed]) != NULL )
                (*captscr_key_scr[key_pressed])( image, DRAW );

        if( (*captscr_key_act[key_pressed]) != NULL )
        {
                ret = (*captscr_key_act[key_pressed])( image );
```

```
                        capt_state=LIFT;
                }

                if (l_edge < far_l_edge)
                        far_l_edge = l_edge;
                if (r_edge > far_r_edge)
                        far_r_edge=r_edge;

        }
        else
        {
                save_columns(&gvram,&data_store,0,scan_line);
                display_columns_4_3(&data_store,&disp_window,0,scan_line);
                capt_state=LIFT;
        }

        break;

    case LIFT:
        /*
        **  wait for the active area to go away
        **  when it does, detect the changed areas and
        **  tag the final image
        */
        if (fz_detect_edges(&central_rows,edge_tol,active_threshold,
                &r_edge,&l_edge))
        {
        }
        else
        {
                turn_grab_off(image.camera);
                capt_state=GONE;
        }
        break;

    case GONE:
        /*
        **  don't do anything
        */
        break;

    default:
        break;
}

key_pressed = OSOPend_key();

/*
**      fix up the data store in case the save key is pressed
**  before the end of the roll
**  Then turn the grabber off and move the data_store
**  back into the grabber main dram.
*/
if(key_pressed == TYPE_SAVE_KEY)
{
        switch (capt_state)
        {
                case BLANK:
                case PRESS:
```

```
VOID load_LUTTBL_to_MinSram (UBYTE *src_ptr)
{
   register ULONG *d;
        register UBYTE *s;
        register LONG ii;

   s = src_ptr;
   d = (ULONG *)MIN_SRAM_BASE;
     , ii = 65536;
      do
      *d++ = *s++;
      while (--ii);

} /* load_LUTTBL_to_MinSram */

/* ------------------------------------------------------------------*/
/*
** Calculate the Min Function and store to the Dram,
** later will copy to MinSram
*/
VOID calculate_minfuncLUT_to_Dram (VOID)
{
   UBYTE a_d, mem, *ptr, out;
   ULONG cond;

   ptr  = (UBYTE *)MINFUNC_LUTTBL;

   for ( mem = 0; mem < 256; mem++ )
      for ( a_d = 0; a_d < 256; a_d++ )
      {
         cond = (UBYTE)floor0 (mem, a_d) * recursive_factor;

         if ( cond >= 50 )
            out = mem - (cond + 50) / 100;
         else if ( cond > 0 )
            out = (UBYTE)floor0 (mem, 1);
         else
            out = mem;

         if (a_d < detect_level)
                       *ptr++ = out | 1;
                    else
                          *ptr++ = out & 0xfe;
      }
} /* calculate_minfuncLUT_to_Dram */

/* ------------------------------------------------------------------*/
/*
** Calculate the Straight Thru and store to the Dram,
** later will copy to MinSram
*/
VOID calculate_straight_thruLUT_to_Dram (VOID)
{
   UBYTE a_d, mem, *ptr;

   ptr = (UBYTE *)STRAIGHT_THRU_LUTTBL;

   for ( mem = 0; mem < 256; mem++ )
        for ( a_d = 0; a_d < 256; a_d++ )
                    if (a_d < 150)
```

```
                *ptr++ = a_d | 1;
              else
                *ptr++ = a_d & 0xfe;

} /* calculate_straight_thruLUT_to_Dram */

/* ----------------------------------------------------------------*/
/*
** Calculate the Tagging function and store to the Dram,
** later will copy to MinSram
*/
VOID calculate_taggingLUT_to_Dram (VOID)
{
    UBYTE a_d, mem, *ptr;
    UBYTE vv;

    ptr = (UBYTE *)FNGR_TAGGING_LUTTBL;

    for ( mem = 0; mem < 256; mem++ )
        for ( a_d = 0; a_d < 256; a_d++ )
        {
            if (changing_threshold > 0)
            {
              vv = ((ULONG)a_d * (ULONG)(100 - changing_threshold) / (ULONG)100);

              if ( (vv < mem) || (a_d < too_dark_value) )
                 *ptr++ = mem & 0xFFFFFFFE;    /* untag (white) */
              else
                 *ptr++ = mem | 1;             /* tag (dark) */
            }
            else
              *ptr++ = mem | 1;
        }
} /* calculate_taggingLUT_to_Dram */

/* ----------------------------------------------------------------*/
/*
** Copy image from MinDram (2048 * 1024) to Dram (ROLL:976, 976... or
** PLAIN:1600, 1600... continuously).
** The image is upside down in MinDram and is stored to Dram rightside up
*/
VOID copy_image_to_Dram (image_type_t camera, ULONG img_store_addr,
    int ht_bytes, int wd_words)
{
    int ii, jj;
    ULONG *src_ptr, *dst_ptr;

    /*
    ** calculate the offset of the active image
    ** NOTE: image offset in copy_image_to_Dram(), load_equref_to_EquDram(),
    **       process_calibration() should be the same.
    */
    dst_ptr = (ULONG *)img_store_addr;
    src_ptr = (ULONG *)MIN_DRAM_BASE;

    if ( camera == ROLL )
        {
        src_ptr += MINDRAM_WD_WORDS * (ht_bytes + MINDRAM_ROLL_ROW_B_OFFSET)
             + MINDRAM_ROLL_COL_W_OFFSET;    /* 512 * (960 + 38) + 24 */
        }
```

```
    else
        {
        src_ptr += MIRDRAM_WD_WORDS * (ht_bytes + MIRDRAM_PLAIN_ROW_B_OFFSET)
            + MIRDRAM_PLAIN_COL_W_OFFSET;   /* 512 * (9.6 + 31) + 39 */
        }

    for ( ii = 0; ii < ht_bytes; ii++ )
    {
        for ( jj = 0; jj < wd_words; jj++ )
            *dst_ptr++ = *src_ptr++;

        /*
        ** go to the beginning of the previous row
        */
        src_ptr -= MIRDRAM_WD_WORDS + wd_words;
    }
} /* copy_image_to_Dram */

/* ------------------------------------------------------------------*/
/*
** copy the equalize reference of the given camera from the Dram to EquDram
*/
VOID load_equref_to_EquDram (image_type_t camera)
{
    ULONG *src_ptr, *dst_ptr;
    ULONG offset_level;
    int wd_words, ht_bytes;
    int ii, jj, equ_exists;
    ULONG dark_offset = 0;
        register ULONG *s,*d;

    if ( camera == ROLL )
        {
        ht_bytes = ROLL_HT_BYTES;
        wd_words = ROLL_WD_WORDS;
        src_ptr = (ULONG *)ROLL_EQU_REFTBL;
        equ_exists = rollequ_exists;
        offset_level = roll_offset;
        }
    else
        {
        ht_bytes = PLAIN_HT_BYTES;
        wd_words = PLAIN_WD_WORDS;
        src_ptr = (ULONG *)PLAIN_EQU_REFTBL;
        equ_exists = plainequ_exists;
        offset_level = plain_offset;
        }

    if ( equ_exists )
    {
        /*
        ** if the equalization reference exists we get the value of the
        ** dark offset calculated from the peak level of
        ** the dark image histogram.
        */
        dark_offset = *(UBYTE *)src_ptr;

        /*
        ** The image at the EquDram should be exactly as MirDram. So use all
        ** MirDram defines.
```

```
** calculate the offset of the active image
** NOTE: image offset in copy_image_to_Dram(),
**       load_equref_to_EquDram(), process_calibration() should be
**       the same.
*/
dst_ptr = (ULONG *)EQU_DRAM_BASE;

 if ( camera == ROLL )
    {
    dst_ptr += MINDRAM_WD_WORDS * (ht_bytes + MINDRAM_ROLL_ROW_B_OFFSET)
        + MINDRAM_ROLL_COL_W_OFFSET;    /* 512 * (960 + 38) + 26 */
    }
 else
    {
    dst_ptr += MINDRAM_WD_WORDS * (ht_bytes + MINDRAM_PLAIN_ROW_B_OFFSET)
        + MINDRAM_PLAIN_COL_W_OFFSET;   /* 512 * (976 + 31) + 39 */
    }

          /*
  ** transfer the bytes to the words
  */
          s = src_ptr;
          ii=ht_bytes;
      do
      {
              d = dst_ptr;
              jj=wd_words;
              do
              {
                      *d++ = *s++;
              } while (--jj);
      dst_ptr -= MINDRAM_WD_WORDS;

       } while (--ii);

    #if IMG_DEBUG
    load_straight_thruLUT_MEM_to_EquSram ();
    #else
    load_equLUT_to_EQUSram (offset_level,dark_offset,desired_equ_value);
    #endif
 }
 else
 {
    load_straight_thruLUT_to_EquSram ();
 }

 equref_camera = camera;
} /* load_equref_to_EquDram */

#else /* PALM_SCANNER */
.----------------------------------------------------------------------*/
/* --------------------------------------------------------------------
/*
** Calculate the Straight Thru and store to the MinSram for PALM scanner
*/
VOID load_straight_thruLUT_to_MinSram (VOID)
{
    ULONG a_d, mem, *ptr;

    ptr = (ULONG *)MIN_SRAM_BASE;
```

```
    for ( mem = 0; mem < 256; mem++ )
        for ( a_d = 0; a_d < 256; a_d++ )
            {
            *ptr++ = a_d | 1;
            }
} /* load_straight_thruLUT_to_MinSram */

/* ---------------------------------------------------------------*/
/*
** copy the equalize reference of PALM from the Dram to EquDram
*/
VOID load_palm_equref_to_EquDram (VOID)
{
    UBYTE *src_ptr;
    ULONG *dst_ptr;
    int ii;
    ULONG dark_offset;

    if ( palmequ_exists )
        {
        src_ptr = (UBYTE *)PALM_EQU_REFTBL;
        dst_ptr = (ULONG *)EQU_DRAM_BASE;

        /*
        ** we get the value of the dark offset calculated from the peak
        ** level of the dark image histogram.
        */
        dark_offset = *(ULONG *)src_ptr;

        src_ptr += 7;

        for ( ii = 0; ii < PALM_WD_PIXELS; ii++ )
            *dst_ptr++ = *src_ptr++;

#if IMG_DEBUG
        load_straight_thruLUT_MEM_to_EquSram ();
#else
        load_equLUT_to_EQUSram (palm_offset,dark_offset,desired_equ_value);
#endif
        }
    else
        load_straight_thruLUT_to_EquSram ();

    equref_camera = PALM_SCAN;
} /* load_equref_to_EquDram */

#endif   /* PALM_SCANNER */

/*
** below functions are common for finger scanner and palm scanner
*/

/* ---------------------------------------------------------------*/
/*
** Calculate the equalize LUT TABLE and store to the EQU_SRAM
*/
VOID load_equLUT_to_EQUSram (ULONG offset, ULONG dark_offset, ULONG desired)
{
    ULONG a_d, mem, *ptr, out, vv, ee;
```

```
    ptr = (ULONG *)EQU_SRAM_BASE;

    for ( a_d = 0; a_d < 256; a_d++ )
        for ( mem = 0; mem < 256; mem++ )
        {
            ee = floor0 (mem, dark_offset);

            if ( ee != 0 )
            {
                out = (ULONG)(desired+offset) *
                    floor0(a_d,dark_offset) / ee;
                if (out > offset)
                    out = out - offset;
                else out = 0;
            }
            else
                out = 256;

            if ( out < 0 )
                out = 0;

            if ( out > 256 )
                out = 256;

            *ptr++ = out | 1;
        }
} /* load_equLUT_to_EQUSram */

/* ----------------------------------------------------------------*/
/*
** Calculate the Straight Thru of new image and store to the Equ Sram
*/
VOID load_straight_thruLUT_to_EquSram (VOID)
{
    ULONG a_d, mem, *ptr;

    ptr = (ULONG *)EQU_SRAM_BASE;

    for ( a_d = 0; a_d < 256; a_d++ )
        for ( mem = 0; mem < 256; mem++ )
            {
            *ptr++ = a_d | 1;
            }
} /* load_straight_thruLUT_to_EquSram */

#if IMG_DEBUG
/* ----------------------------------------------------------------*/
/*
** Calculate the Straight Thru of memory's image and store to the Equ Sram
** NOTE: This routine is for debugging purpose
*/
VOID load_straight_thruLUT_MEM_to_EquSram (VOID)
{
    ULONG a_d, mem, *ptr;

    ptr = (ULONG *)EQU_SRAM_BASE;

    for ( a_d = 0; a_d < 256; a_d++ )
        for ( mem = 0; mem < 256; mem++ )
```

```
            {
            *ptr++ = mem | 1;
            }
} /* load_straight_thruLUT_MEM_to_Equdram */
#endif

/* ---------------------------------------------------------------------*/
/*
** Calculate the division to get rid of the overflow
*/
ULONG floor0 (ULONG a, ULONG b)
{
    if ( a >= b )
        return (a - b);
    else
        return (0);
} /* floor0 */

/* ---------------------------------------------------------------------*/
/*
** Setup the basic graphic function
*/
void setup_graphic (void)
{
    set_config (0, 10);
    clear_whole_screen();

    smlfont_id = install_font (&corpus29);
    bigfont_id = install_font (&corpus49);

    talon_font[CORPUS29] = install_font (&corpus29);
    talon_font[CORPUS49] = install_font (&corpus49);

    select_font (smlfont_id);
    get_fontinfo (smlfont_id, &fontinfo);
    smlfont_charhigh = fontinfo.charhigh;
    smlfont_charwide = fontinfo.charwide;

    select_font (bigfont_id);
    get_fontinfo (bigfont_id, &fontinfo);
    bigfont_charhigh = fontinfo.charhigh;
    bigfont_charwide = fontinfo.charwide;
} /* setup_graphic */


/* end of gsp_init.c */
```

```
/* ----------------------------------------------------------------------
 *
 * File name: userintf.c
 *
 * Purpose:   User interface on scanner for talon 1000.
 *
 * Date:      Jan-05-94
 *
 * Author:    Ellen Yu
 *
 * History:
 *  05-12-94 Joyce Young, fill MinDram with 0xFFFFFFFF is not needed.
 *  06-13-94 Joyce Young, add #ifndef NPA for NPA
 *  06-30-94 Ellen Yu,    turn grabber on 2 frame in PrevInitAct
 *  09-12-94 Joyce Young, add display_text() to display general message to
 *           call text_out() & kanji_out() seperately
 *  09/22/94 JY, move setup of talon_font(CORPUS29) & talon_font(CORPUS49)
 *           from PrintTitle() to setup_graphic(), otherwise, if calling
 *           PrintTitle() several times, will mess up the talon_font table
 *  11-15-94 JY, delete #ifndef NPA, so keep displaying MINfunc image
 *  11-17-94 JY, add text_length() to get text length to call text_width()
 *           & kanji_length() seperately
 *  11/18/94 JY, delete CAPT_ABORT case
 *  12-21-94 EY, fixed displaying MINfunc image
 *  01/21/95 JY, delete unnecessary include files
 *  02/17/95 TS, moved out button action routines to fngrcapt
 * -------------------------------------------------------------------- */


/* ------------------------------- Includes ------------------------------ */
#include "stdtypes.h"
#include "colordef.h"
#include "coorddef.h"
#include "gsp_defs.h"
#include "gsp_font.h"
#include "gsp_text.h"
#include "imgglobs.h"
#include "mem_allc.h"


/* ------------------------- External Functions ------------------------- */

/* --------------------------------- Prototype ---------------------------- */
VOID PrintTitle (VOID);
VOID display_text (SHORT xx, SHORT yy, VOID *string, SHORT knj_font);
SHORT text_length (VOID *string, SHORT knj_font);


/* ------------------------------ Global Vars ----------------------------- */
SCRTEXT_T titletext[] =
{
   { CORPUS49, GREY6, WHITE, TITLE_TXT_X,     TITLE_TXT_Y,     TITLE_TXT_X,
     TITLE_FONT_H,      0, TITLE_TXT },
   { CORPUS49, GREY4, WHITE, COPYRIGHT_TXT_X, COPYRIGHT_TXT_Y, COPYRIGHT_TXT_X,
     COPYRIGHT_FONT_H,  0, COPYRIGHT_TXT },
#ifndef PALM_SCANNER
   { CORPUS29, GREY6, WHITE, VERSION_TXT_X,   VERSION_TXT_Y,   VERSION_TXT_X,
     VERSION_FONT_H,    0, FNGR_VER_TXT }
#else
   { CORPUS29, GREY6, WHITE, VERSION_TXT_X,   VERSION_TXT_Y,   VERSION_TXT_X,
```

```
    VERSION_FONT_H,    0, PALM_VER_TXT )
#endif
);


/* ------------------------------------------------------------------- */


/* ------------------------------------------------------------------- */
/*
** Display the given string on the (xx, yy) position for either English or
** Kanji
*/
VOID display_text (SHORT xx, SHORT yy, VOID *string, SHORT knj_font)
{
#ifndef KANJI
   text_out (xx, yy, (char *)string);
#else
   kanji_out (xx, yy, (SHORT *)string, knj_font);
#endif
} /* display_text */

/* ------------------------------------------------------------------- */
/*
** Get the length of the given string either for English or for Kanji
*/
SHORT text_length (VOID *string, SHORT knj_font)
{
   short txt_w;

#ifndef KANJI
   txt_w = text_width ((char *)string);
#else
   txt_w = kanji_length ((SHORT *)string, knj_font);
#endif

   return (txt_w);
} /* text_length */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 *
 * Func name: PrintTitle()
 *
 * Purpose:   Display the TALON 1000 title and copyright
 *
 * Date:      Jan-05-96
 *
 * Author:    Ellen Yu
 *
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
VOID PrintTitle (VOID)
{
    SCRTEXT_T *txtptr;
    short txt_w;

    /*
    ** Company title
    */
    txtptr = &titletext[0];
    set_colors( txtptr->fcolor, txtptr->bcolor );
```

```
select_font( talon_font(txtptr->font) );

txt_w = text_width ( txtptr->strptr );
txtptr->xposn = (SCR_W - txt_w) / 2;
text_out( txtptr->xposn, txtptr->yposn, txtptr->strptr );

/*
** Copyright
*/
txtptr = &titletext[1];
set_colors( txtptr->fcolor, txtptr->bcolor );
select_font( talon_font(txtptr->font) );

txt_w = text_width ( txtptr->strptr );
txtptr->xposn = (SCR_W - txt_w) / 2;
text_out( txtptr->xposn, txtptr->yposn, txtptr->strptr );

/*
** Version and type of scanner
*/
txtptr = &titletext[2];
set_colors( txtptr->fcolor, txtptr->bcolor );
select_font( talon_font(txtptr->font) );

txt_w = text_width ( txtptr->strptr );
txtptr->xposn = (SCR_W - txt_w) / 2;
text_out( txtptr->xposn, txtptr->yposn, txtptr->strptr );

} /* PrintTitle */

/* end of userintf.c */
```

```
/* ---------------------------------------------------------------
 * File name: mimio.c
 * Purpose:   Routines for handling memory images in the 34010.
 * Date:      Oct-05-93
 * Author:    Tom Sartor
 * History:
 * --------------------------------------------------------------- */

/* ------------------------------ Includes ----------------------------- */
#include "mimio.h"

void byteblt(),bytefill();

/* ------------------------------------------------------------------ */
void mim_new(d,a,i,w,h)
MIM *d;
unsigned char *a;
int i,w,h;
{
    d->a = a;
    d->i = i;
    d->w = w;
    d->h = h;
}

/* ------------------------------------------------------------------ */
void mim_subset(s,d,x,y,w,h)
MIM *s,*d;
int x,y,w,h;
{
    d->i = s->i;
    d->a = (s->a)+x+y*(d->i);
    d->w = w;
    d->h = h;
}

/* ------------------------------------------------------------------ */
void mim_move(s,d)
MIM *s,*d;
{
    byteblt(s->a,(s->i)<<3,d->a,(d->i)<<3,s->h,s->w,0x000c);
}

/* ------------------------------------------------------------------ */
void mim_move_c(s,d,c)
MIM *s,*d;
int c;
{
    byteblt(s->a,(s->i)<<3,d->a,(d->i)<<3,s->h,s->w,c);
}

/* ------------------------------------------------------------------ */
unsigned char * mim_adr(s,x,y)
MIM *s;
int x,y;
{
    return((s->a)+x+y*(s->i));
}

/* ------------------------------------------------------------------ */
```

```
void mim_size(s, w, h)
MIM *s;
int *w,*h;
{
    *w = s->w;
    *h = s->h;
}

/* ------------------------------------------------------------------------ */
int mim_inc(s)
MIM *s;
{
        return(s->i);
}

/* ------------------------------------------------------------------------ */
void mim_fill(d, v)
MIM *d;
int v;
{
    bytefill(v&0xff,d->a,(d->i)<<3,d->h,d->w,0x000c);
}

/* ------------------------------------------------------------------------ */
void mim_fill_c(d, v, c)
MIM *d;
int v,c;
{
    bytefill(v&0xff,d->a,(d->i)<<3,d->h,d->w,c);
}

/* ------------------------------------------------------------------------ */
/* end of mimio.c */
```

```
/*
** Filename: grabber.c
** Purpose:  Routines to handle the Grabber.
** Date:     11/16/93
** Author:   Joyce Young
** History:
**  05/05/94 Joyce Young, Add mask register for display (GRABBER_CTRL1_BASE)
**  01/04/95 Ellen Yu, Change identatin style.
**  04/13/95 ts - added different turn_grab_on_normal, modified turn_off,
**                and moved prototypes to gsp_func.h
**  04/19/95 EY - Added comments.
*/

#include "stdtypes.h"
#include "img_defs.h"
#include "mem_addr.h"
#include "gsp_func.h"

/* ---------------------------------------------------------------------*/
/*
** Initialize the GSP Grabber: setup the Video Control and Grabber Control.
*/
VOID init_gsp_grabber (VOID)
{
/*
** Setup the Video Control:
**  read the System Resources (address is the same as Video Control),
**  if the value of the SVGA Sync input detected (bit 6) is 0 (normal is 1),
**  then set Video Source as External Sync Source (bit1-0 = 01), otherwise,
**  set as Internal Sync Source (bit1-0 = 00).
**
*/
   *(ULONG *)VIDEO_CONTROL_BASE = 0x00000000;
   *(ULONG *)GRABBER_CTRL1_BASE = 0xFFFFFFFF;

   /*
   ** Turn the Grabber Off
   */
   turn_grab_off (ROLL);
} /* init_gsp_grabber */

/* ---------------------------------------------------------------------*/
/*
** Turn Grab off, polling Grabber status till off (bit0 = 0).
*/
VOID turn_grab_off (image_type_t camera)
{
#ifndef DISABLE_GRAB
   /*--- Be sure bit 7 be cleared, no image reduction ---*/
   if ( camera == ROLL )
       *(UBYTE *)GRABBER_CTRL0_BASE = 0x70;
   else
       *(UBYTE *)GRABBER_CTRL0_BASE = 0xE0;

   /*
   ** wait for Grab is disabled (BIT0 becomes 1)
   */
   while ( !((*(UBYTE *)GRABBER_CTRL0_BASE) & 1) )
       ;
```

```
    /*
    ** wait for the VBLANK start
    ** NOTE: need to wait VBLANK off/on, otherwise, Grabber sometimes does not
    **   really turn off
    */
    while ( !((*(UBYTE *)GRABBER_CTRLO_BASE) & 2) )
        ;

    while ( ((*(UBYTE *)GRABBER_CTRLO_BASE) & 2) )
        ;
#endif
} /* turn_grab_off */

/* ---------------------------------------------------------------------*/
/*
** Turn Grabber on with reduced display
** polling Grabber status till on (bit0 = 1).
*/
VOID turn_grab_on (image_type_t camera, int frame_num)
{
#ifndef DISABLE_GRAB
    int ii;

    if ( camera == ROLL )
        *(UBYTE *)GRABBER_CTRLO_BASE = 0xFF;
    else
        *(UBYTE *)GRABBER_CTRLO_BASE = 0xEF;

    /*
    ** wait for Grab is enabled (BIT0 becomes 0)
    */
    while ( ((*(UBYTE *)GRABBER_CTRLO_BASE) & 1) )
        ;

    for ( ii = 0; ii < frame_num; ii++ )
        {
        while ( !((*(UBYTE *)GRABBER_CTRLO_BASE) & 2) )
            ;

        while ( ((*(UBYTE *)GRABBER_CTRLO_BASE) & 2) )
            ;
        }
#endif
} /* turn_grab_on */

/* ---------------------------------------------------------------------*/
/*
** Turn Grabber on with normal display
** polling Grabber status till on (bit0 = 1).
*/
VOID turn_grab_on_normal (image_type_t camera, int frame_num)
{
#ifndef DISABLE_GRAB
    int ii;

    if ( camera == ROLL )
        *(UBYTE *)GRABBER_CTRLO_BASE = 0x7F;
    else
        *(UBYTE *)GRABBER_CTRLO_BASE = 0xEF;
```

```
*/
typedef enum image_type_t
{
  ROLL,
  PLAIN,
  PALM_SCAN,
  NON_CAMERA
} image_type_t;

#endif   /* IMG_DEFS_H */
```

```
/*
** Filename: img_defs.h
** Purpose: Definitions to handle the images display or capture for Host,
**          DSP and GSP.
** Date:    10/11/93
** Author:  Joyce Young
** Revised:
**  11/02/93 - Ellen Yu
**  01/28/94 - Joyce Young, Add ROLL_RESOLUTION & PLAIN_RESOLUTION
**  02/02/94 - Ellen Yu, Seperate into img_defs.h and imgglobs.h.
**  02/02/94 - Joyce Young, Add the definitions for the PALM camera
**  11/21/94 - JY, Add #ifdef NEW_PALM to support new PALM
**  01/13/95 - JY, change palm pixels for new NPA palm
*/

#ifndef IMG_DEFS_H
#define IMG_DEFS_H

#define ROLL_WD_BYTES          960
#define ROLL_WD_WORDS          (ROLL_WD_BYTES / 4)
#define ROLL_HT_BYTES          960
#define ROLL_WD_PIXELS         960
#define ROLL_HT_PIXELS         960
#define ROLL_HT_RESOLUTION     600
#define ROLL_VT_RESOLUTION     600
#define ROLL_BIT_PERPIXEL      8

#define PLAIN_WD_BYTES         1600
#define PLAIN_WD_WORDS         (PLAIN_WD_BYTES / 4)
#define PLAIN_HT_BYTES         976
#define PLAIN_WD_PIXELS        1600
#define PLAIN_HT_PIXELS        976
#define PLAIN_HT_RESOLUTION    500
#define PLAIN_VT_RESOLUTION    500
#define PLAIN_BIT_PERPIXEL     8

#ifdef NEW_PALM
#define PALM_WD_PIXELS         2400        /* pixels per row */
#define PALM_HT_PIXELS         2040        /* rows */
#define PALM_HT_RESOLUTION     508
#define PALM_VT_RESOLUTION     508
#define PALM_BIT_PERPIXEL      8
#define HEEL_WD_PIXELS         2400        /* pixels per row */
#define HEEL_HT_PIXELS         1040        /* rows */
#define HEEL_HT_RESOLUTION     PALM_HT_RESOLUTION
#define HEEL_VT_RESOLUTION     PALM_VT_RESOLUTION
#define HEEL_BIT_PERPIXEL      8
#else
#define PALM_WD_BYTES          2748
#define PALM_WD_WORDS          (PALM_WD_BYTES / 4)
#define PALM_HT_BYTES          2748
#define PALM_WD_PIXELS         PALM_WD_BYTES
#define PALM_HT_PIXELS         PALM_HT_BYTES
#define PALM_HT_RESOLUTION     500
#define PALM_VT_RESOLUTION     500
#define PALM_BIT_PERPIXEL      8
#endif

/*
** ROLL: must be 0
```

```
#endif  /* DSP_MAP */

#endif  /* MEM_ALLC_H */
```

```
** GSP_COFF_PROGRAM will be stored after all tables, then followed by
** FINAL_IMAGE_ADDR.
*/
#define  DSPGSP_CMND_BUF          0xC0002000       /* 0x100W  */

/*
** The order of the PC_PARAMETERS (ULONG):
**   For Finger scanner
**        1. flag of the ROLL  equalization file exists (1=exists)
**        2. flag of the PLAIN equalization file exists (1=exists)
**        3. flag of the parameter file exists (1=exists)
**        4.... the numbers of the values in the para.dat file if exists
**
**   For Palm scanner
**        1. flag of the PALM equalization file (palm.equ) exists (1=exists)
**        2. flag of the PALM dewarping file    (palm.wrp) exists (1=exists)
*/
#define  PC_PARAMETERS            0xC0004000       /* 0x40    */

/*
** The general return results of GSP command processing, defined in the
** scancmd.h, will be stored after all image parameters in PC_PARAMETERS.
** If total numbers of the image parameters exceed to 0x40 in the future,
** this address needs to be changed.
*/
#define  COMMAND_RETURN_RESULTS   0xC0004600       /* reserved 10W spaces */

/*
** below for Finger scanner
*/
#define  STRAIGHT_THRU_LUTTBL     0xC0004800       /* 0x4000   256*256/4 */
#define  MINFUNC_LUTTBL           0xC0084800       /* 0x4000   256*256/4 */
#define  FNGR_TAGGING_LUTTBL      0xC0104800       /* 0x4000   256*256/4 */
#define  ROLL_EQU_REFTBL          0xC0184800       /* 0x38400  960*960/4 */
#define  PLAIN_EQU_REFTBL         0xC088C800       /* 0x5F500 1600*976/4 */

/*
** GDRAM address in fngrgspe.cmd & fngrgspj.cmd need to be matched with
** FNGR_GSP_COFF_PROGRAM. If any one been changed, change the other, too
*/
#define  FNGR_GSP_COFF_PROGRAM    0xC1476800       /* 0x7000  */
#define  FNGR_FINAL_IMAGE_ADDR    0xC6000000

/*
** below for PALM scanner
*/
/*
** GDRAM address in palmgspe.cmd & palmgspj.cmd need to be matched with
** PALM_GSP_COFF_PROGRAM. If any one been changed, change the other, too
*/
#define  PALM_EQU_REFTBL          0xC0004800       /* 2400/4 */
#define  PALM_GSP_COFF_PROGRAM    0xC000C800       /* 0x7000  */

#ifndef NEW_PALM
#define  PALM_FINAL_IMAGE_ADDR    0xC00EC800       /* 2748*2748/4=0x1CCE84 */
#else
#define  PALM_DEWARP_TBL          0xC00EC800       /* 0x300 (3072/4) */
#define  HEEL_FINAL_IMAGE_ADDR    0xC00F2800       /* 2400*1040/4=0x98580 */
#define  PALM_FINAL_IMAGE_ADDR    0xC13FD800       /* 2400*2040/4=0x12ad40 */
#endif
```

```
**      1. flag of the ROLL  equalization file exists (1=exists)
**      2. flag of the PLAIN equalization file exists (1=exists)
**      3. flag of the parameter file exists (1=exists)
**      4.... the numbers of the values in the para.dat file if exists
**
**  For Palm scanner
**      1. flag of the PALM equalization file (palm.equ) exists (1=exists)
**      2. flag of the PALM dewarping file    (palm.wrp) exists (1=exists)
*/
#define  PC_PARAMETERS              0xC00200       /* 0x40    */

/*
** The results of the platen check for the finger scanner, defined in the
** structure of platen_check_result_t in scancmd.h, will be stored after
** all image parameters in PC_PARAMETERS.
** If total numbers of the image parameters exceed to 0x40 in the future,
** this address needs to be changed.
*/
#define  COMMAND_RETURN_RESULTS   0xC00230       /* reserved 10W spaces */

/*
** below for finger scanner
*/
#define  STRAIGHT_THRU_LUTTBL       0xC00240       /* 0x4000   256*256/4 */
#define  MINFUNC_LUTTBL             0xC04240       /* 0x4000   256*256/4 */
#define  FNGR_TAGGING_LUTTBL        0xC08240       /* 0x4000   256*256/4 */
#define  ROLL_EQU_REFTBL            0xC0C240       /* 0x38400  960*960/4 */
#define  PLAIN_EQU_REFTBL           0xC44640       /* 0x5F500 1600*976/4 */

/*
** GDRAM address in fngrgspe.cmd & fngrgspj.cmd need to be matched with
** FNGR_GSP_COFF_PROGRAM. If any one been changed, change the other, too
*/
#define  FNGR_GSP_COFF_PROGRAM    0xCA3840       /* 0x7000  */
#define  FNGR_FINAL_IMAGE_ADDR    0xF00000

/*
** below for PALM scanner
*/
/*
** GDRAM address in palmgspe.cmd & palmgspj.cmd need to be matched with
** PALM_GSP_COFF_PROGRAM. If any one been changed, change the other, too
*/
#define  PALM_EQU_REFTBL            0xC00240       /* 2400/4 */
#define  PALM_GSP_COFF_PROGRAM      0xC00640       /* 0x7000 */

#ifndef NEW_PALM
#define  PALM_FINAL_IMAGE_ADDR      0xC07640       /* 2748*2748/4=0x1CCE84 */
#else
#define  PALM_DEWARP_TBL            0xC07640       /* 0x300 (3072/4) */
#define  HEEL_FINAL_IMAGE_ADDR      0xC07940       /* 2400*1040/4=0x98580 */
#define  PALM_FINAL_IMAGE_ADDR      0xC9FEC0       /* 2400*2040/4=0x12ad40 */
#endif

#else    /* GSP_MAP */

/*
** Dram area to store the image process by WORD length:
** The first 2 items, DSPGSP_CMD_BUF, PC_PARAMETERS will be the same area
** to the finger scanner and the palm scanner.
```

```
/*
** Filename: mem_allc.h
** Purpose:  Definition of memory allocation of software.
**           If the program wants to run GSP/RAMDAC/8051 functions under
**           the DSP map, add the compiler option -dDSP_MAP; otherwise,
**           those functions will run under GSP map.
** Date:     05/27/94
** Author:   Joyce Young
** History:
**   02/04/94 Joyce Young, Add the definitions of the GSP DRAM BANKs
**   03/15/94 Joyce Young, Rearrange the DramBanks
**   04/07/94 Joyce Young, Rearrange the DramBanks to support Kanji
**   05/20/94 Ellen Yu,    Removed unnecessary define's. Changed the
**                 FNGR_FINAL_IMAGE_ADDR from 0xE00000 to 0xF00000
**   06/07/94 Joyce Young, add COMMAND_RETURN_RESULTS to support platen check.
**   06/13/94 Joyce Young, modify the comments
**   11/22/94 JY, add #ifndef NEW_PALM to support new PALM
**   01/18/95 JY, modify for palm tables
*/

#ifndef MEM_ALLC_H
#define MEM_ALLC_H

/*
** Below memory maps are different from DSP and GSP.
** We use the same name on the both GSP and DSP codes, but
** compile with -dDSP_MAP option if the program is emulated on DSP or
** compile without -dDSP_MAP option if the program is emulated on GSP.
*/

#ifdef DSP_MAP

/*
**  NOTE: finger scanner will use Bank0 & Bank3,
**        palm scanner will use all banks.
**        If any address is changed in mem_addr.h, make sure the address here
**        will be matched.
**                           +-----------------+
**  DramBank0:   0xC00100   | 1M words valid  |
**                           +-----------------+
**  DramBank1:   0xD00000   | 1M words valid  |
**                           +-----------------+
**  DramBank2:   0xE00000   | 1M words valid  |
**                           +-----------------+
**  DramBank3:   0xF00000   | 1M words valid  |
**                           +-----------------+
*/

/*
** Dram area to store the image process by WORD length:
** The first 2 items, DSPGSP_CMD_BUF, PC_PARAMETERS will be the same area
** to the finger scanner and the palm scanner.
** GSP_COFF_PROGRAM will be stored after all tables, then followed by
** FINAL_IMAGE_ADDR.
*/
#define  DSPGSP_CMD_BUF          0xC00100       /* 0x100W  */

/*
** The order of the PC_PARAMETERS (ULONG):
**   For finger scanner
```

```
/*
** Filename: imgglobs.h
** Purpose:  Definition & variables to handle the images display or capture
**           on DSP/GSP.
** Date:     10/11/93
** Author:   Joyce Young
** Revised:
**   11/02/93 - Ellen Yu
**   06/07/94 - Ellen Yu, Support platen check function, add dirty_threshold
**              and damage_threshold to the image_object_t structure.
**   11/18/94 - JY, delete CAPT_ABORT in capture_t;
**              expand length of ic_name in image_object_t
**   12/21/94 - JY, add CAPT_NULL & CAPT_SAVE_PALM in capture_t
*/

#include "stdtypes.h"

#ifndef IMGGLOBS_H
#define IMGGLOBS_H

typedef enum capture_t
{
    CAPT_NO_RESPONSE,
    CAPT_SAVEING,       /* ROLL or PLAIN for finger, PALM & HEEL for palm */
    CAPT_MISSFNG,       /* missing finger/hand */
    CAPT_WRONG_TYPE,    /* image type and finger mismatched */
    CAPT_NULL,          /* 4 reserved for ADMIT_ABORT */
    CAPT_SAVE_PALM      /* save PALM only; only used by palm scanner */
} capture_t;

/*
** If MAX_NAME_LEN in scancmnd.h expands, ic_name needs to expand too.
*/
typedef struct image_object_t
{
   ULONG ic_cmd;             /* ROLL, PLAIN */
   ULONG ic_size;                   /* sizeof (image_object_t)/sizeof (ULONG) */
   ULONG ic_scantype;        /* STYPE_... */
   ULONG ic_imgtype;         /* ROLL, PLAIN or PALM */
   ULONG ic_set;             /* OR of shifted image IDs */
   ULONG ic_addr;            /* the address of image */
   ULONG ic_name[11];/* convict name (4 chars/ULONG) */
   ULONG ic_reserve1;
        ULONG ic_dirty_threshold;
        ULONG ic_damage_threshold;
   ULONG ic_reserve2;
   ULONG ic_flag;            /* the flag indicate all words written */
} image_object_t;


#endif   /* IMGGLOBS_H */
```

```
/*
** Filename: gsp_func.h
** Purpose:  function prototypes
** Date:     04-19-95
** Author:   Ellen Yu
** History:
*/

/* ---------------------------- grabber.c ------------------------------*/
VOID init_gsp_grabber (VOID);
VOID turn_grab_off (image_type_t camera);
VOID turn_grab_on (image_type_t camera, int frame_num);
VOID turn_grab_on_normal (image_type_t camera, int frame_num);
VOID wait_for_grab_VBLANK_on_off (VOID);
```

```
/* $Header:   G:/t1000/gsp/mimio.h_v   1.0   08 Apr 1995 11:06:02   TOM  $ */
/*
 * $Log:   G:/t1000/gsp/mimio.h_v  $
 *
 *    Rev 1.0   08 Apr 1995 11:06:02   TOM
 * Initial revision.
 *
 *    Rev 1.2   26 Oct 1992 17:44:50   TOM
 * added mim_fill declarations
 *
 *    Rev 1.1   16 Oct 1992 01:52:10   TOM
 *
 *    Rev 1.0   16 Sep 1992 18:41:04   TOM
 * Initial revision.
 */
/******************************************
file: mimio.h

definitions for memory image segments
only 8-bit pixels are allowed

*/

typedef struct mimage {
    unsigned char *a;          /* address of first element of first row */
    int   i;                   /* increment in bytes  from row to row  */
    int   w;                   /* image width */
    int   h;                   /* image height */
} MIM;

void mim_new(MIM *d,unsigned char *a,int i,int w,int h );
void mim_subset( MIM *s,MIM *d,int x,int y,int w,int h );
void mim_move( MIM *s,MIM *d );
void mim_move_c( MIM *s MIM *d,int c);
void mim_op_move( MIM *s,MIM *d );
unsigned char *mim_adr( MIM *s,int x,int y );
void mim_size( MIM *s, int *w, int *h );
int mim_inc( MIM *s);
void mim_fill( MIM *d, int v );
void mim_fill_c( MIM *d, int v, int c );
```

```
/*
** Filename: gsp_imgs.h
** Purpose:  Definition & variables to handle the images display or capture.
** Date:     18/01/94
** Author:   Ellen Yu
** History:
**  02/20/94 Joyce Young, modify the MINDRAM offset
**  06/03/94 Joyce Young, adjust the offset of ROLL/PLAIN active image in
**           MINDRAM for new board
**  06/09/94 Ellen Yu, add #define PROTOTYPE difference the hardware
**           prototype board and other new revisions.
*/

#ifndef GSP_IMGS_H
#define GSP_IMGS_H

#define  MINDRAM_WD_BYTES        2048
#define  MINDRAM_WD_WORDS        (MINDRAM_WD_BYTES / 4)
#define  MINDRAM_HT_BYTES        1024
#define  MINDRAM_PITCH_BYTES     2048
#define  MINDRAM_PITCH_BITS      (MINDRAM_PITCH_BYTES * 8)     /* 0x4000 */
#ifndef PROTOTYPE
#define  MINDRAM_ROLL_ROW_B_OFFSET   38
#define  MINDRAM_ROLL_COL_W_OFFSET   24
#define  MINDRAM_ROLL_COL_B_OFFSET   (MINDRAM_ROLL_COL_W_OFFSET * 4)
#define  MINDRAM_PLAIN_ROW_B_OFFSET  31
#define  MINDRAM_PLAIN_COL_W_OFFSET  38
#define  MINDRAM_PLAIN_COL_B_OFFSET  (MINDRAM_PLAIN_COL_W_OFFSET * 4)
#else
#define  MINDRAM_ROW_B_OFFSET  32
#define  MINDRAM_COL_W_OFFSET  24
#define  MINDRAM_COL_B_OFFSET  (MINDRAM_COL_W_OFFSET * 4)
#define  MINDRAM_PLAIN_COL_W_OFFSET  13
#define  MINDRAM_PLAIN_COL_B_OFFSET  (MINDRAM_PLAIN_COL_W_OFFSET * 4)
#endif

#define  GRBVRAM_WD_BYTES        1024
#define  GRBVRAM_HT_BYTES        1024
#define  GRBVRAM_PITCH_BYTES     1024
#define  GRBVRAM_PITCH_BITS      (GRBVRAM_PITCH_BYTES * 8)     /* 0x2000 */

#define  DPYVRAM_WD_BYTES        1024
#define  DPYVRAM_HT_BYTES        1024
#define  DPYVRAM_PITCH_BYTES     1024
#define  DPYVRAM_PITCH_BITS      (1024 * 8)     /* 0x2000 */

#define  ROLL_PITCH_BYTES        1024
#define  ROLL_PITCH_BITS         (ROLL_PITCH_BYTES * 8)
#define  ROLL_GRBVRAM_PITCH      (-(GRBVRAM_PITCH_BITS * 4))
#define  ROLL_DPYVRAM_PITCH      (DPYVRAM_PITCH_BITS * 3)
#define  ROLL_DYDX_VAL           ((((IMG_ROLL_H - 12) / 3) << 16) | (IMG_ROLL_W - 16))

#define  PLAIN_PITCH_BYTES       2048
#define  PLAIN_PITCH_BITS        (PLAIN_PITCH_BYTES * 8)
#define  PLAIN_GRBVRAM_PITCH     (-(GRBVRAM_PITCH_BITS * 2))
#define  PLAIN_DPYVRAM_PITCH     (DPYVRAM_PITCH_BITS)
#define  PLAIN_DYDX_VAL          ((IMG_PLAIN_H - 12) << 16) | (IMG_PLAIN_W - 12)


#endif   /* GSP_IMGS_H */
```

```
    ERASE,
    DRAW
} TEXT_OPER_T;

typedef enum
{
    SCAN_KEY,
    SAVE_KEY
} KEY_TYPE;

typedef enum
{
    RET_ERR_ADDR,
    READ_FOREVER,
    WRITE_FOREVER
} MEM_TEST_RESULT_TYPE;

typedef enum
{
    UNPRESSED_BUTTON,
    PRESSED_BUTTON
} BUTTON_OPER_TYPE;

/*
** Attributes for text displayed on screen
*/
typedef struct
{
    short   font;       /* font index of the talon_font table */
    short   fcolor;     /* foreground color */
    short   bcolor;     /* background color */
    short   xposn;      /* x position */
    short   yposn;      /* y position */
    short   align;      /* Alignment (relative to baseline or topleft) */
    short   font_h;     /* height of font */
    short   text_w;     /* width of text string */
    char    *strptr;    /* text string ptr */
} SCRTEXT_T;

typedef struct
{
    image_type_t  camera;
    HAND_TYPE     hand;
    scan_type_t   fng_num;
    ULONG         store_addr;
    UBYTE         *src_addr;
    UBYTE         *dst_addr;
} IMAGE_ATTR_T;


#endif  /* GSP_DEFS_H */
```

```
typedef enum
{
    PREV_ROLL,
    PREV_PLAIN,
    PREV_MISSING,
    PREV_YES,
    PREV_NO,
    PREV_MISFNG,
    CAPT_REPEAT,
    CAPT_NEXT,
    CAPT_FINGER,
    PLACE_START,
    PLACE_ABORT,
    ROLL_CONTINUE,
    ROLL_YES
} KEYACT_TYPE;

typedef enum
{
        RIGHT,
        LEFT
} HAND_TYPE;

typedef enum
        {
        ROLL_RIGHT_THUMB,           /* 0  */
        ROLL_RIGHT_INDEX,           /* 1  */
        ROLL_RIGHT_MIDDLE,          /* 2  */
        ROLL_RIGHT_RING,            /* 3  */
        ROLL_RIGHT_LITTLE,          /* 4  */
        ROLL_LEFT_THUMB,            /* 5  */
        ROLL_LEFT_INDEX,            /* 6  */
        ROLL_LEFT_MIDDLE,           /* 7  */
        ROLL_LEFT_RING,             /* 8  */
        ROLL_LEFT_LITTLE,           /* 9  */
        PLAIN_TWO_THUMBS,           /* 10 (unsupported) */
        PLAIN_RIGHT4,               /* 11 */
        PLAIN_LEFT4,                /* 12 */
        RIGHT_PALM,                 /* 13 */
        LEFT_PALM,                  /* 14 */
        PLAIN_RIGHT_THUMB,          /* 15  */
        PLAIN_LEFT_THUMB            /* 16  */
} FINGER_TYPE;

/*
** user-selected type of the key pressed or command for image caputre
*/
typedef enum keytype_t
{
    TYPE_NO_RESPONSE,
    TYPE_SCAN_KEY,
    RELEASE_SCAN_KEY,
    TYPE_SAVE_KEY,
    RELEASE_SAVE_KEY,
    TYPE_ABORT
} keytype_t;

typedef enum
{
```

```
/*
** Filename: gsp_defs.h
** Purpose:  #define in GSP application.
** Date:     10-05-93
** Author:   Ellen Yu
** History:
**  01-31-94 Joyce Young, Changed the src_addr & dst_addr in IMAGE_ATTR_T as
**                        pointer
**  02-25-94 Joyce Young, Added the fng_num in IMAGE_ATTR_T
**  04-01-94 Joyce Young, support KANJI in MODE_TYPE
**  12-19-94 Ellen Yu, remove some unused define
*/

#ifndef GSP_DEFS_H
#define GSP_DEFS_H

#include "img_defs.h"
#include "scancmd.h"

#define NULL   0

#define FALSE  0
#define TRUE   1

/*
**
*/
#define XIE    0x0002
#define HIE    0x0200
#define INTIN  0x0008
#define INTOUT 0x0080

#define BIT0   0x01
#define BIT1   0x02
#define BIT2   0x04
#define BIT3   0x08

/*
**
*/
typedef enum
{
    MODE_ROLL,
    MODE_PLAIN,
    MODE_PREV,
    MODE_CENTR,
    MODE_RARROW,
    MODE_LARROW,
    MODE_PLACEHOLD,
    MODE_PLACEHOLD1,
    MODE_ROLLHOLD,
    MODE_ROLLHOLD1,
    MODE_LIFTHAND
} MODE_TYPE;

typedef enum
{
   FINGER_LEGEND,
   MODE_LEGEND
} MGS_LEGEND_TYPE;
```

```
    /*
    ** wait for Grab is enabled (BIT0 becomes 0)
    */
    while ( ((*(UBYTE *)GRABBER_CTRL0_BASE) & 1) )
        ;

    for ( ii = 0; ii < frame_num; ii++ )
        {
        while ( !((*(UBYTE *)GRABBER_CTRL0_BASE) & 2) )
            ;

        while ( ((*(UBYTE *)GRABBER_CTRL0_BASE) & 2) )
            ;
        }
#endif
} /* turn_grab_on_normal */


/* ------------------------------------------------------------------*/
/*
** wait for the VBLANK start on and off
*/
VOID wait_for_grab_VBLANK_on_off (VOID)
{
#ifndef DISABLE_GRAB
   while ( !((*(UBYTE *)GRABBER_CTRL0_BASE) & 2) )
       ;

   while ( ((*(UBYTE *)GRABBER_CTRL0_BASE) & 2) )
       ;
#endif
} /* wait_for_grab_VBLANK_on_off */


/* end of grabber.c */
```

The present invention has been described in terms of preferred embodiments. The invention, however, is not limited to the embodiments depicted and described. Rather, the scope of the invention is defined by the appended claims.

CLAIMS:

1. A method of reducing smear in a rolled fingerprint image represented by a rolled image array, comprising the steps of:

sequentially generating frames of an optical image signal which includes data values characteristic of light intensities of corresponding locations of an optical image, wherein the optical image includes a fingerprint image of a finger rolling on a surface;

determining, for each frame of the optical image signal, a freeze column representing a line positioned between leading and trailing edges of the fingerprint image and oriented transverse to a direction of roll of the rolling finger;

sequentially updating an interim array that is an accumulation of the frames of the optical image signal and characteristic of an interim image of a rolled fingerprint, a current update of the interim array being formed by reducing pixel values of the interim array by a portion of the difference between corresponding data values from a current frame of the optical image signal and the pixel values of the interim array if the corresponding data values of the current frame of the optical image signal are less than the pixel values of the interim array; and

generating the rolled image array by transferring portions of the interim array to the rolled image array, wherein the transferred portion of the current update of the interim array extends forward in the direction of finger roll from the freeze column determined from a preceding frame of the optical image signal that preceded the current frame of the optical image signal.

2. The method of claim 1, wherein the transferred portion of the current update of the interim

array includes data characteristic of a portion of the interim image up to approximately the leading edge of the rolled fingerprint of the interim image.

3. The method of claim 1, wherein the transferred portion of the current update of the interim array extends up to approximately the freeze column determined from the current frame of the optical image signal.

4. The method of claim 1, wherein the freeze line represented by the freeze column determined from each frame of the optical image signal is positioned at least approximately half a distance in the direction of roll between the leading and trailing edges of the fingerprint image.

5. The method of claim 1, wherein the freeze line represented by the freeze column determined from each frame of the optical image signal is positioned more than half a distance in the direction of roll between the leading and trailing edges of the fingerprint image.

6. The method of claim 1, wherein a first transferred portion of the interim array extends rearward in the direction of finger roll from approximately the freeze column determined from a first frame of the optical image signals.

7. The method of claim 6, wherein the first transferred portion of the interim array is characteristic of a portion of the interim image forward in the direction of roll from about the trailing edge of the first interim image.

8. The method of claim 1, further comprising initializing pixels in the interim array with maximum values.

9. The method of claim 1, further comprising initializing the interim array with data values of a frame of the optical image signal.

10. The method of claim 1, further comprising saving the rolled image array after transferring the portion of a final interim array to the rolled image array.

11. The method of claim 1, further comprising displaying a rolled fingerprint image represented by the rolled image array on a display device as it is generated.

12. The method of claim 11, further comprising decimating the transferred portion such that the rolled image array has fewer pixels than the interim array.

13. The method of claim 1, wherein sequentially updating the interim array includes updating the interim array in real time as frames of the optical image signal are generated, and wherein generating the rolled image array includes transferring a portion of the interim array to the rolled image array in real time as the interim array is updated.

14. The method of claim 1, wherein the transferred portions of the interim array are adjacent and non-overlapping.

15. A method of generating a rolled fingerprint image array characteristic of a rolled fingerprint image, comprising the steps of:

generating a series of frames of an optical image signal characteristic of an optical image of a finger rolling on a surface at sequential times, wherein the frames include data, the value of each datum being characteristic of a light intensity of a corresponding location of the optical image of the rolling finger;

determining a freeze column from each frame, wherein each freeze column is representative of a position between leading and trailing edges of the corresponding optical image of the rolling finger;

sequentially updating an interim array in an image memory with the frames as they are generated, the interim array being characteristic of an interim image of a rolled fingerprint that has a leading edge and a trailing edge, including first updating the interim array by transferring a first one of the optical image signals to the image memory, and then further updating the interim array by reducing pixel values of the interim array with a portion of the difference between corresponding data values of a current frame and the pixel values of the interim array if the corresponding data values of the current frame indicate a darker image than the pixel values of the interim array;

associating the freeze columns determined from the frames with corresponding updates of the interim array; and

sequentially updating the rolled fingerprint image array in an output memory with the updates of the interim array by sequentially transferring a portion of each update of the interim array to the output memory, including transferring a portion of the first update of the interim array that extends in a direction of finger

roll rearward from approximately the freeze column associated with the first updated interim array, and then transferring a portion of a subsequent update of the interim array that extends forward in the direction of finger roll from approximately the freeze column associated with a preceding update of the interim array.

16. The method of claim 15, wherein the transferred portion for a subsequent update of the interim array extends forward only to the freeze column of the subsequently updated interim array.

17. The method of claim 15, wherein the transferred portions of sequential updates of the interim array are adjacent and non-overlapping.

18. The method of claim 15, wherein the transferred portions of sequential updates of the interim array are adjacent and do not overlap rearward in the direction of finger roll from the freeze column determined from the preceding optical image signal.

19. A device for reducing smear in a rolled fingerprint image represented by a rolled image array, comprising:

an imaging system for sequentially generating frames of a series of electronic signals characteristic of an optical image that includes a fingerprint image of a finger rolling on a surface;

means for sequentially generating frames of an optical image signal in response to the electronic signals, each optical image signal including data, the value of each datum being characteristic of a light intensity of a corresponding location of the optical image;

an image capture system responsive to the optical image signals for sequentially updating an interim array characteristic of an interim image of a rolled fingerprint that has a leading edge and a trailing edge, a current update of the interim array being formed from a preceding update of the interim array and a current frame of the optical image signal by reducing pixel values of the preceding update of the interim array with a portion of the difference between the corresponding data values of the current frame and the pixel values of the preceding update of the interim array if the corresponding data values of the current frame are characteristic of darker images than the pixel values of the preceding update of the interim array;

means for determining, for each frame of the optical image signal, a freeze column representing a line positioned between leading and trailing edges of the fingerprint image and oriented transverse to a direction of roll of the rolling finger; and

means for generating the rolled image array by transferring a portion of the current interim array to the rolled image array, wherein the transferred portion of the current interim array extends forward in the direction of finger roll from the freeze column determined from a preceding frame of the optical image signal that preceded the current frame of the optical image signal.

20. The method of claim 1, wherein the current update of the interim array F^n is formed according to the relation:

$$F^n = F^{n-1} - K*(F^{n-1} - I^n),$$

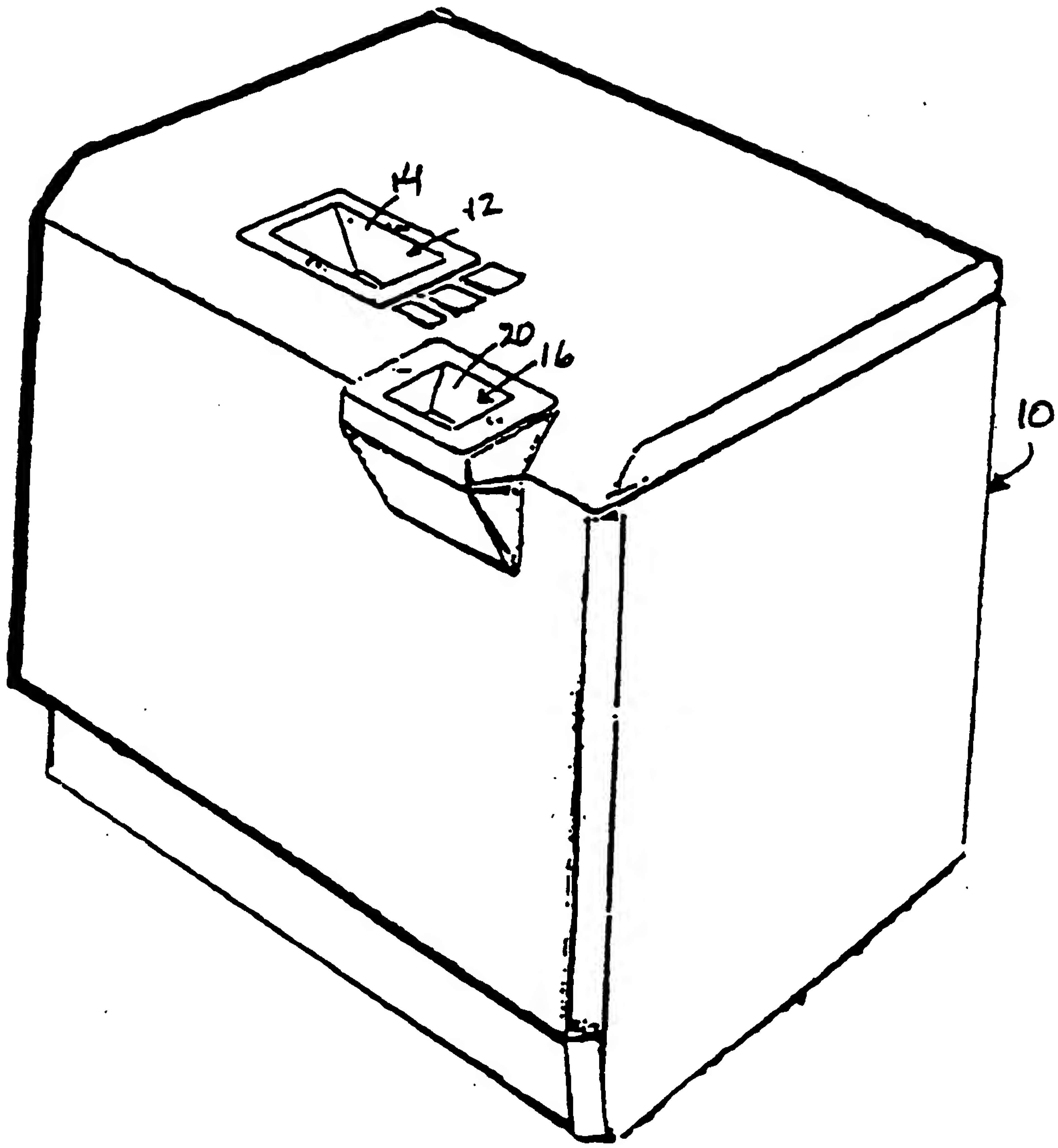
where F^n is a pixel value of the current update of interim array, F^{n-1} is the pixel value of interim array, I^n is the

corresponding data value of the optical image signal, and K is a factor less than or equal to one.

21. The method of claim 20, wherein K is in a range of 0.25 to 0.5.

22. The method of claim 20, wherein K is approximately 0.33.

Fig. 1



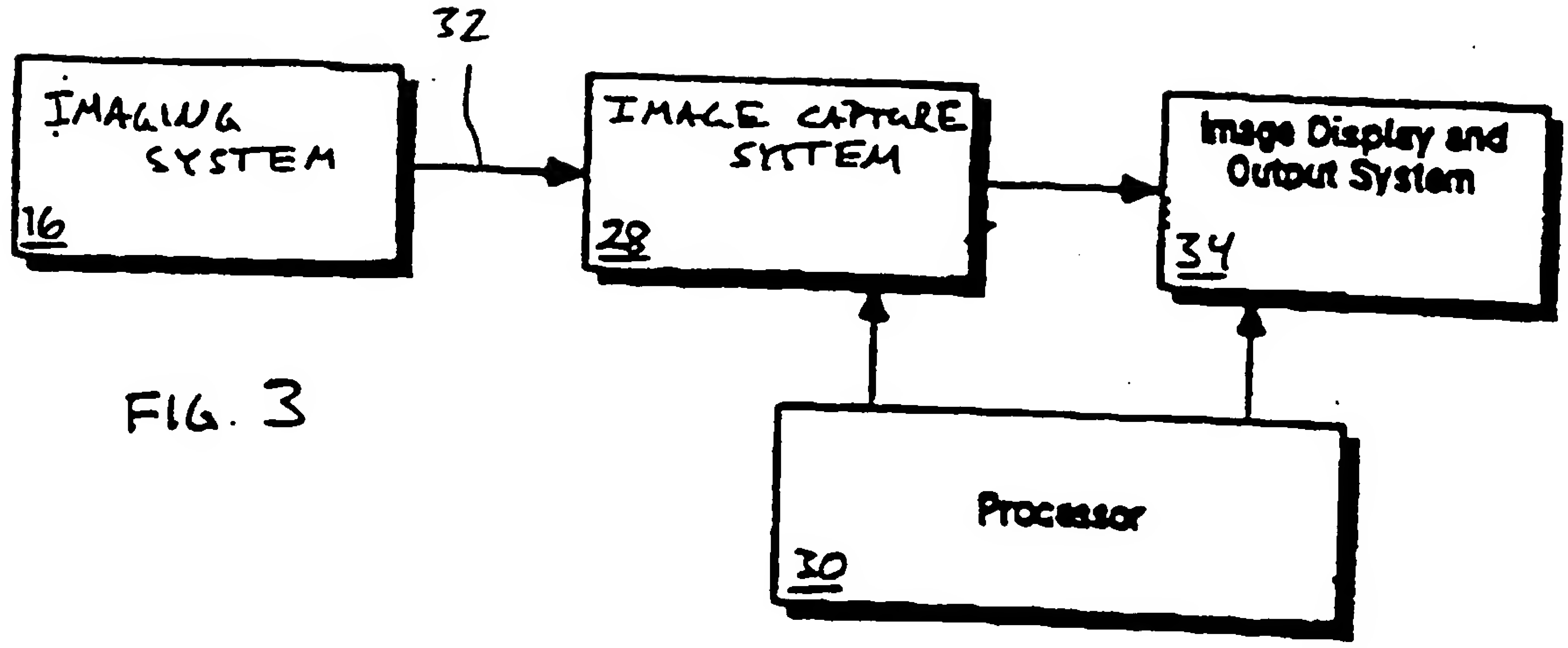


FIG. 3

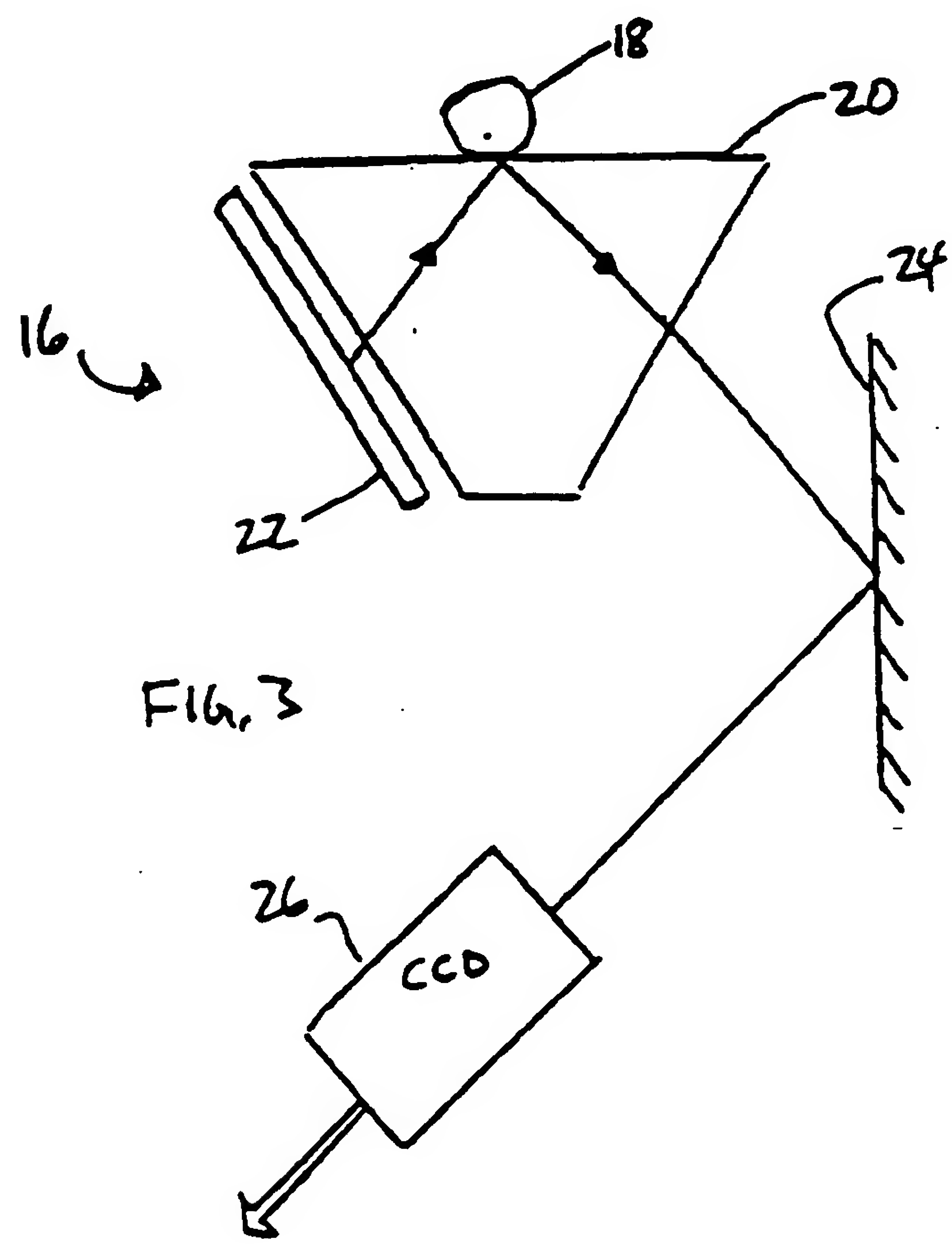
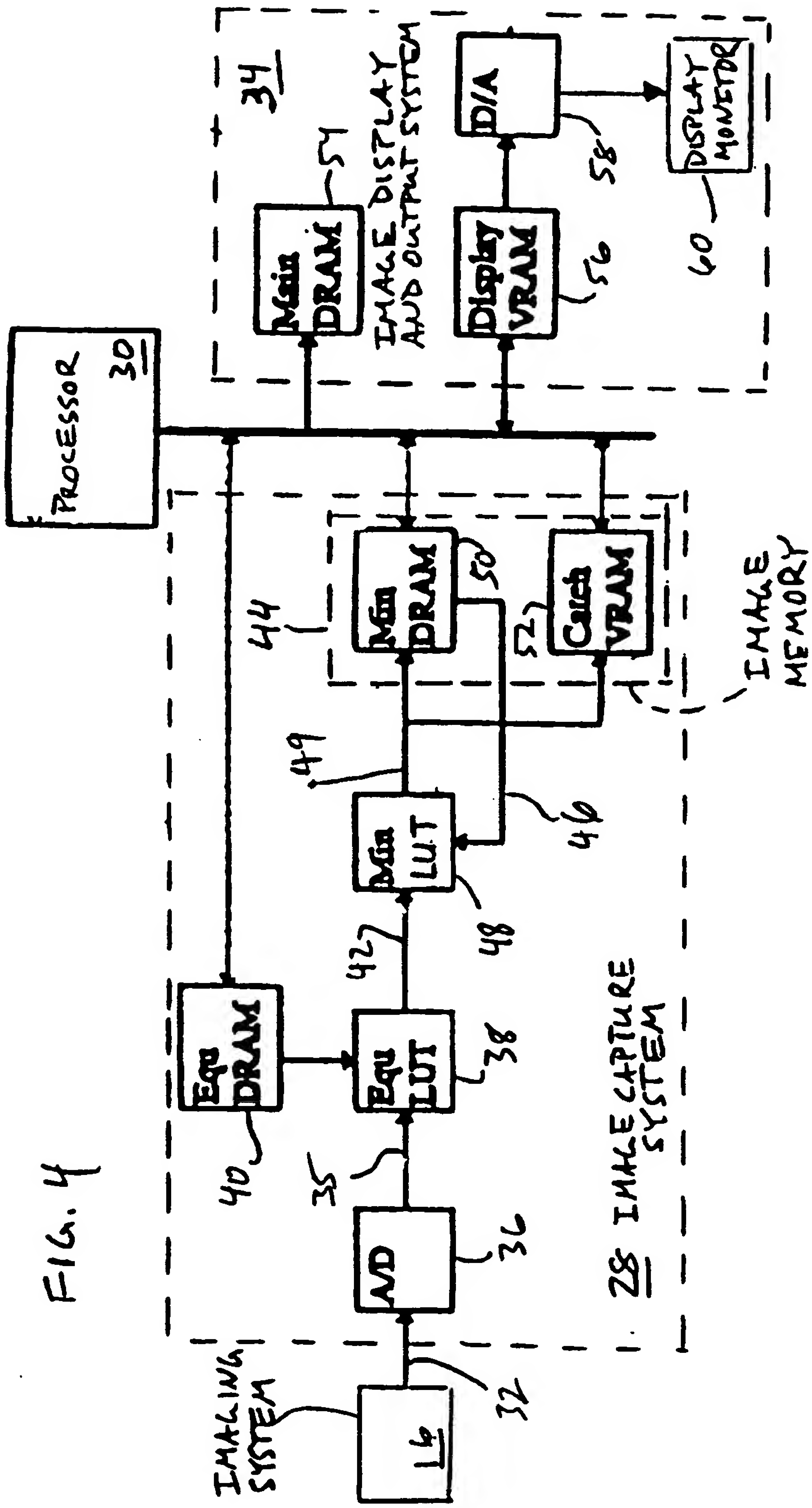


FIG. 2
PRIOR ART



PROCESSOR
30
34
IMAGE DISPLAY AND OUTPUT SYSTEM
Main DRAM
54
Display VRAM
56
D/A
58
DISPLAY MONITOR
60
Mem DRAM
50
Catch VRAM
52
44
IMAGE MEMORY
49
Mem LUT
46
48
42
Equ DRAM
40
Equ LUT
38
35
A/D
36
28 IMAGE CAPTURE SYSTEM
16
IMAGING SYSTEM
32

FIG. 4

Fig. 5A

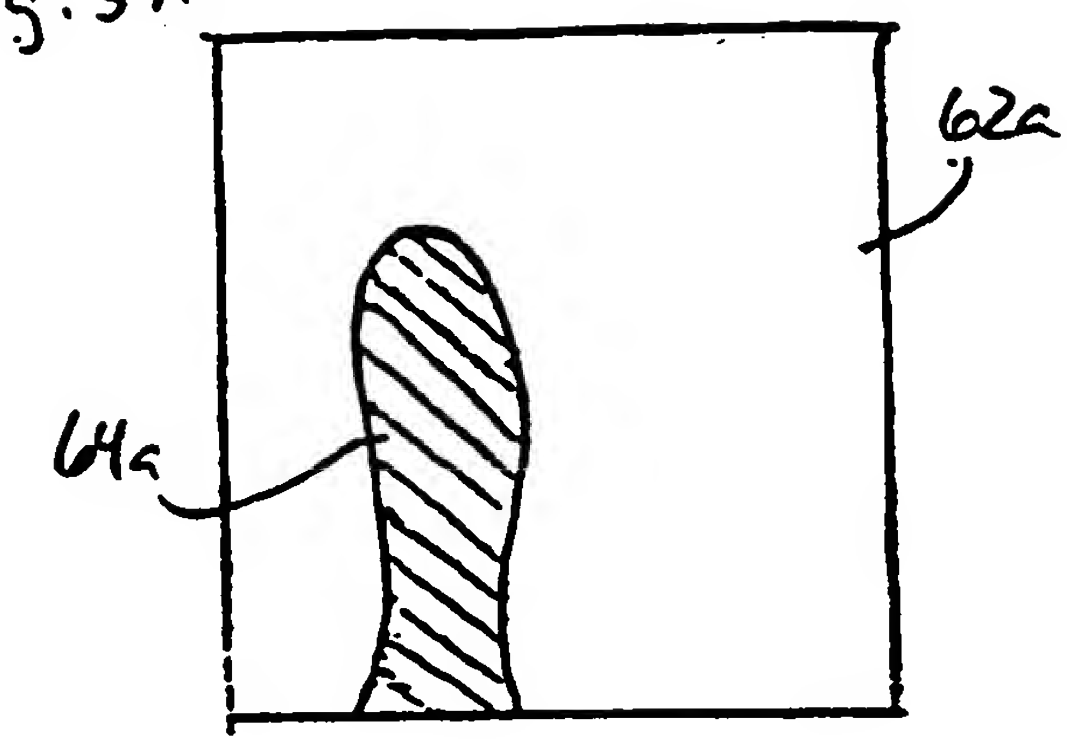


Fig. 5D

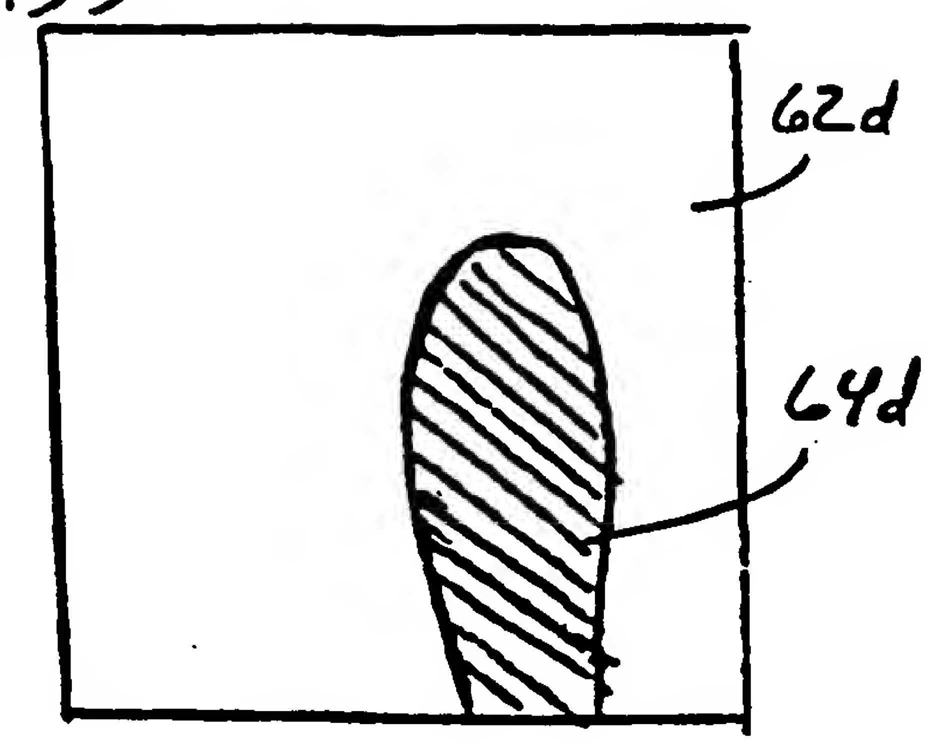


Fig. 5B

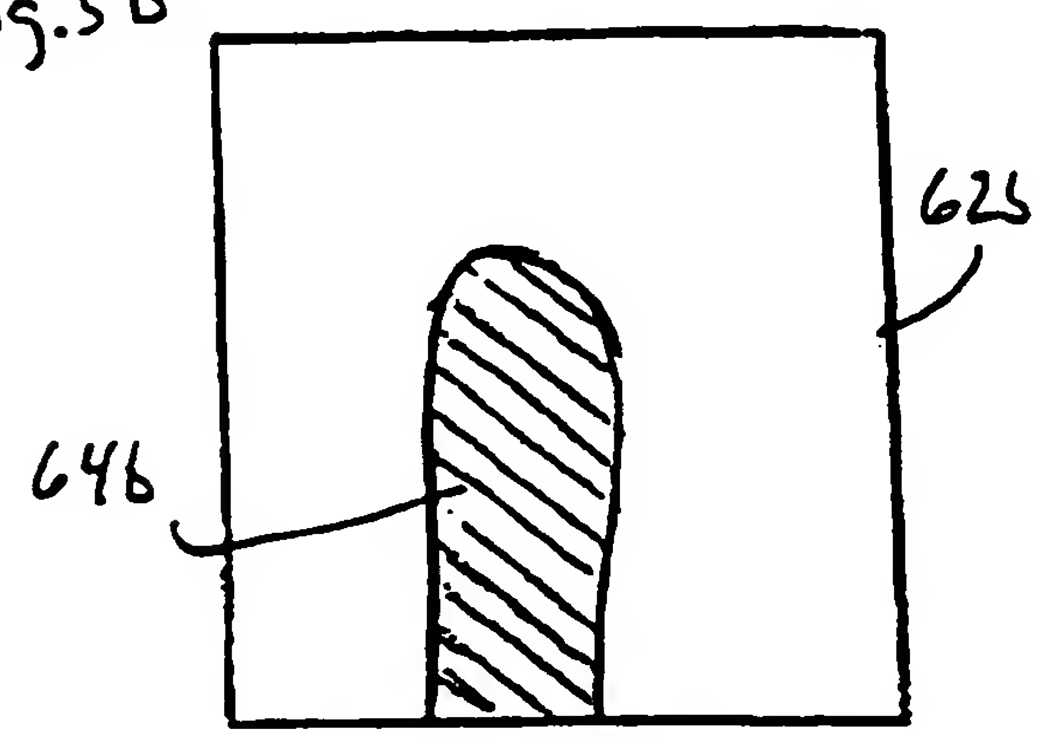


Fig. 5E

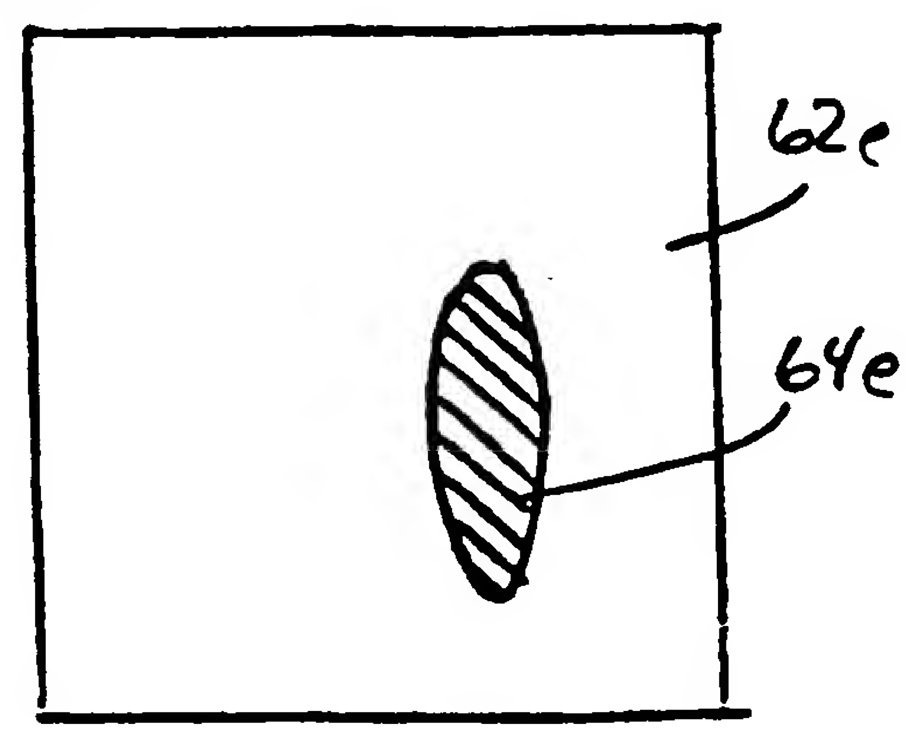


Fig. 5C

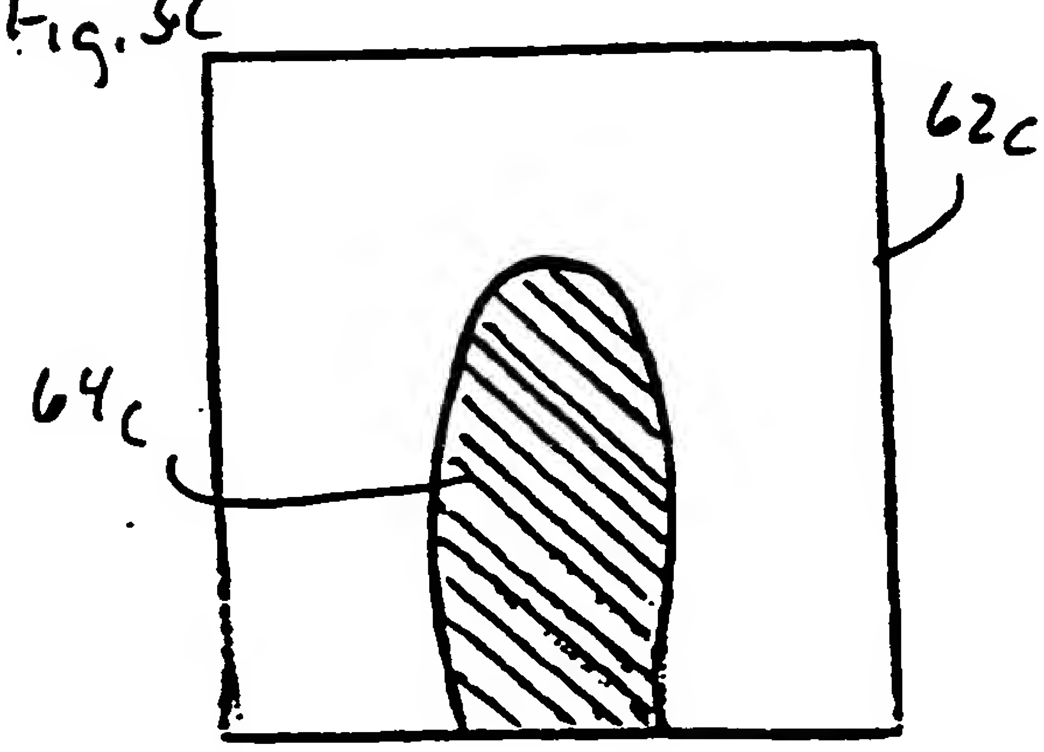


Fig. 6A

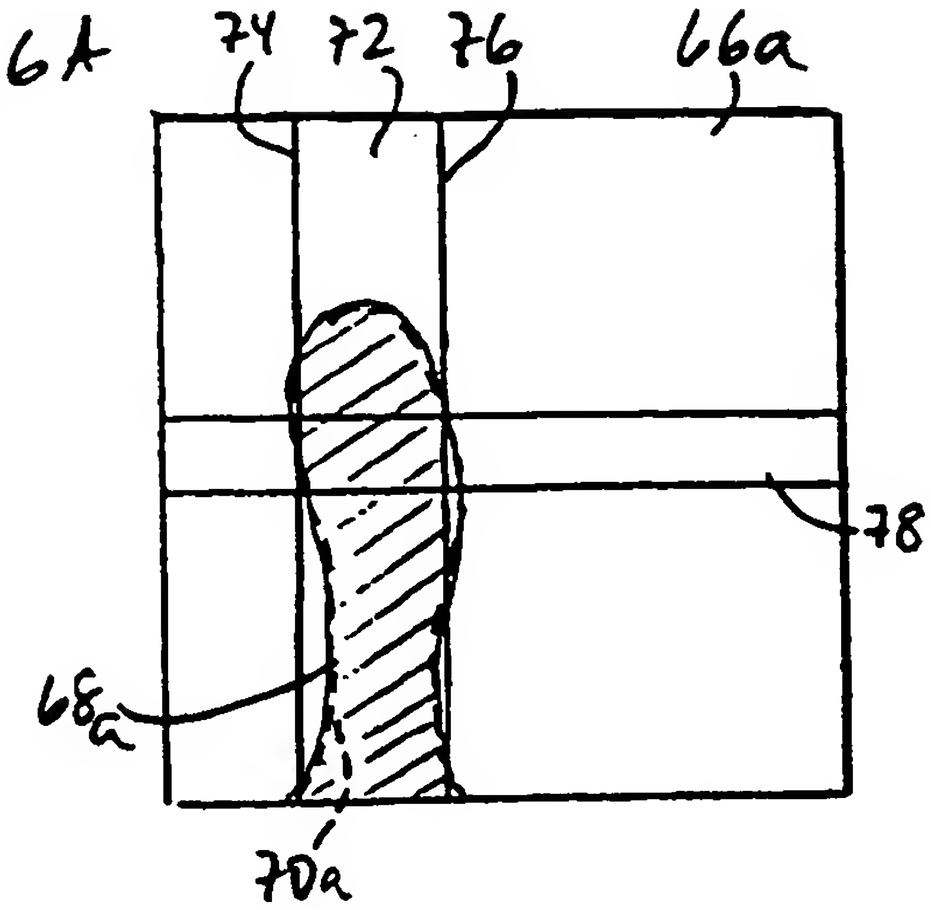


Fig. 6D

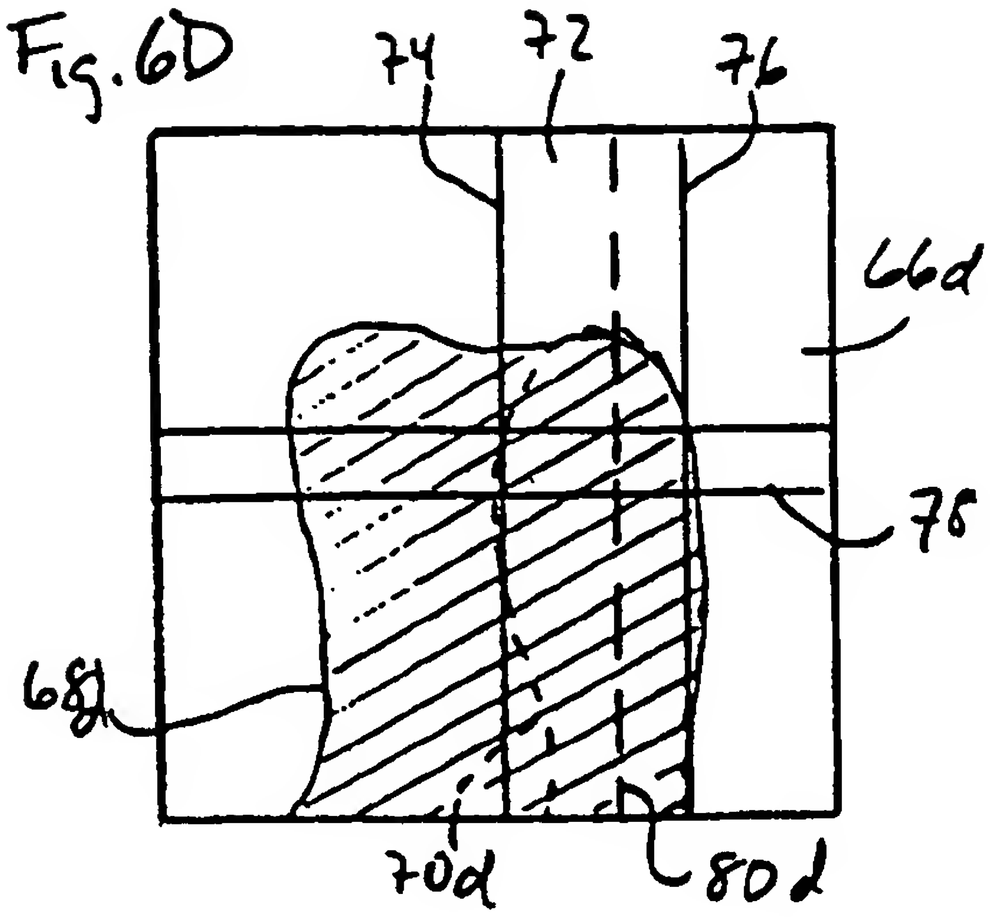


Fig. 6B

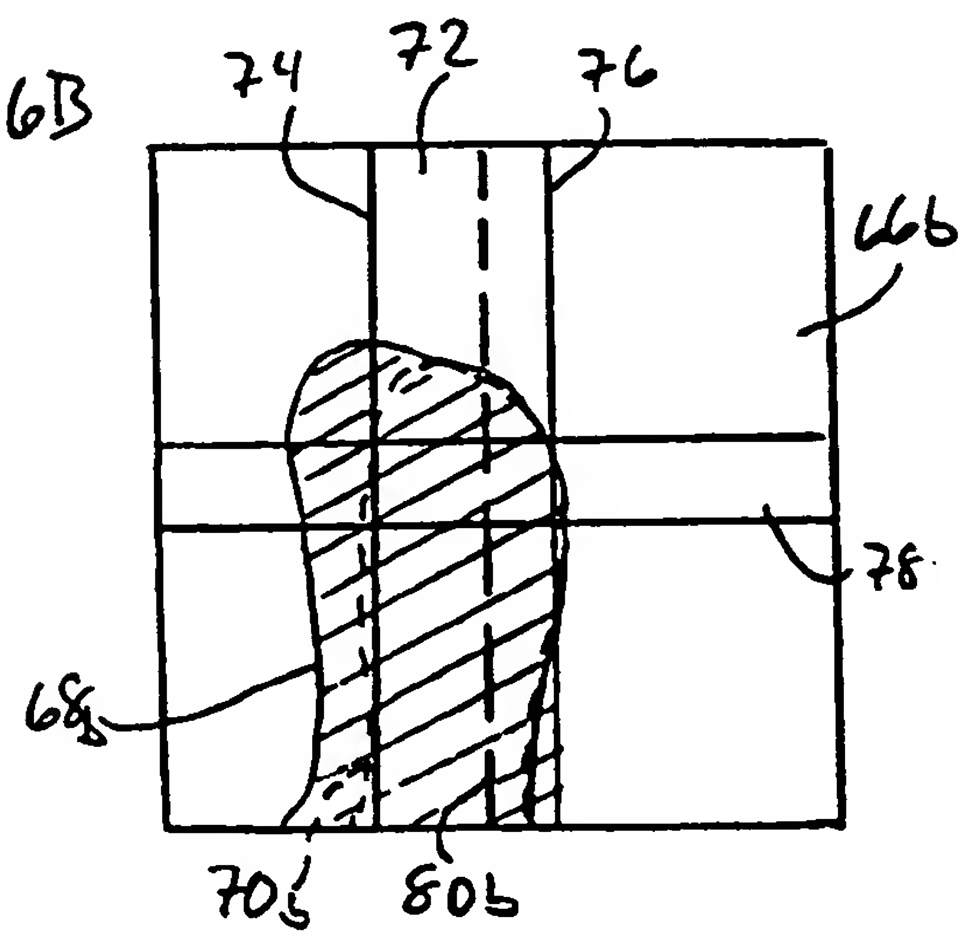


Fig. 6E

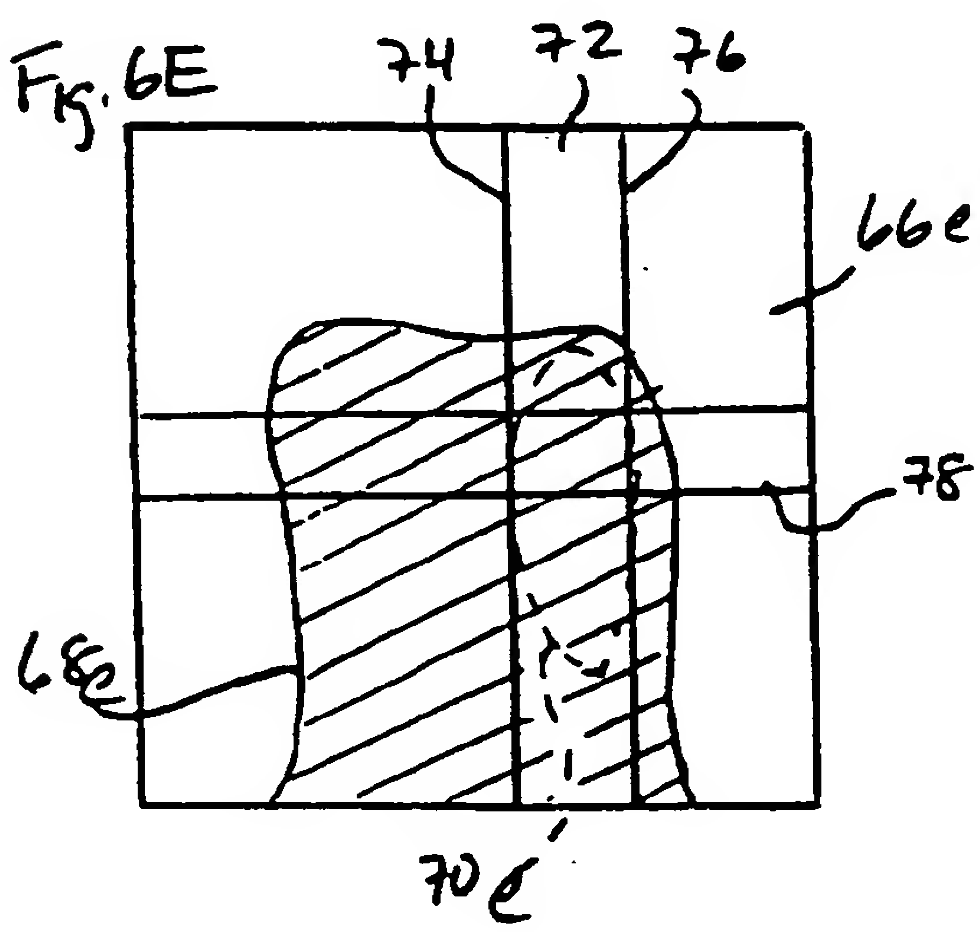


Fig. 6C

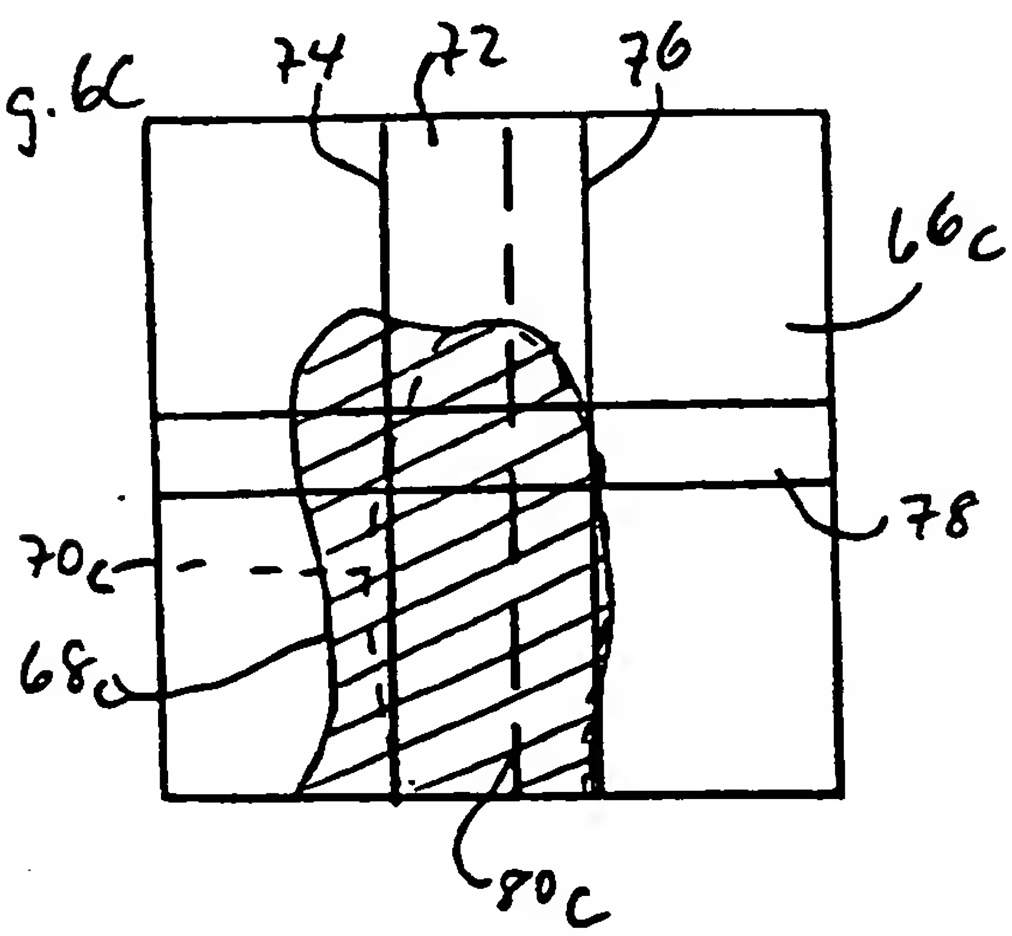


Fig 7A

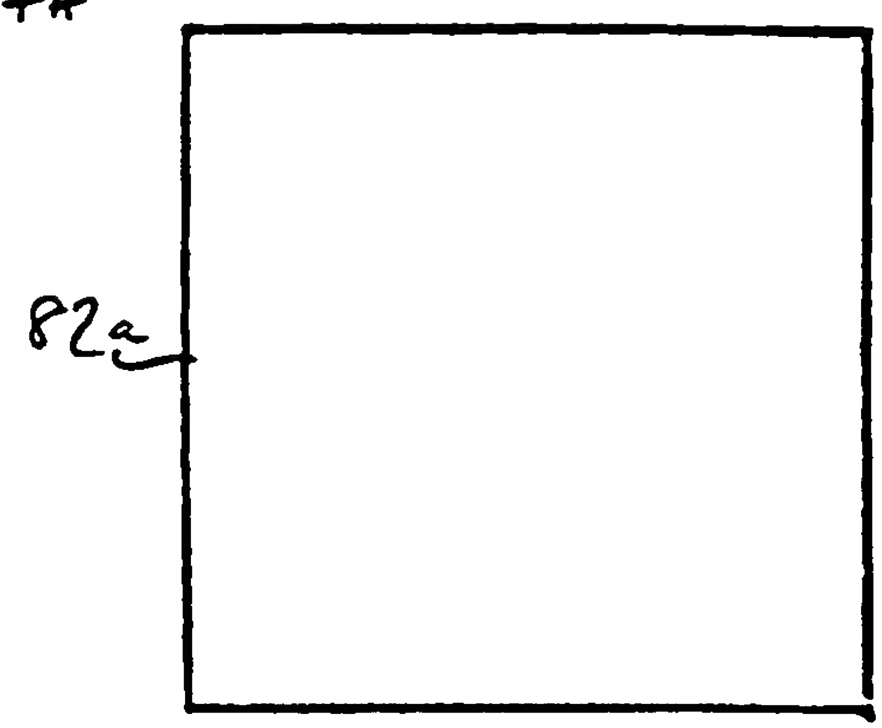


Fig. 7D

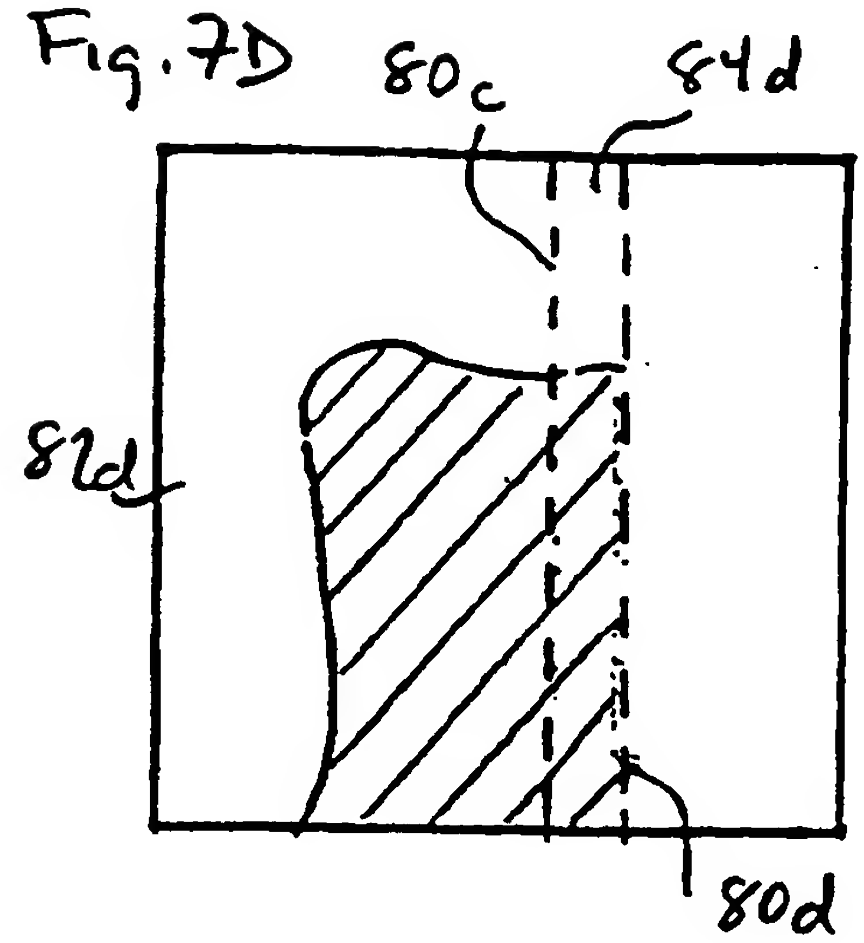


Fig. 7B

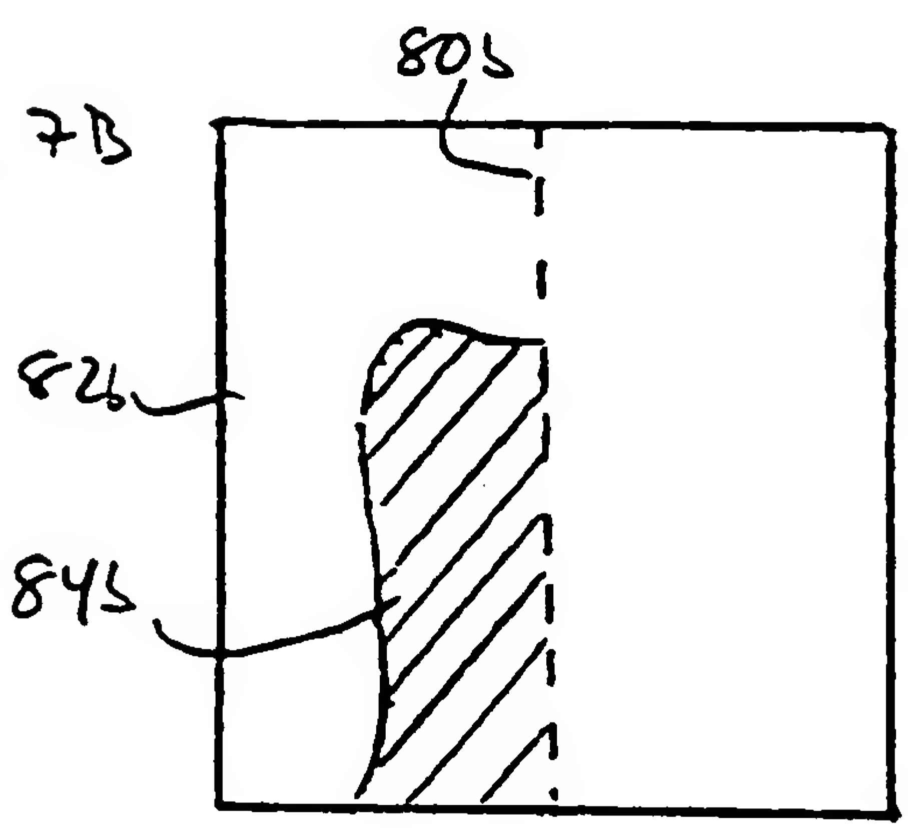


Fig. 7E

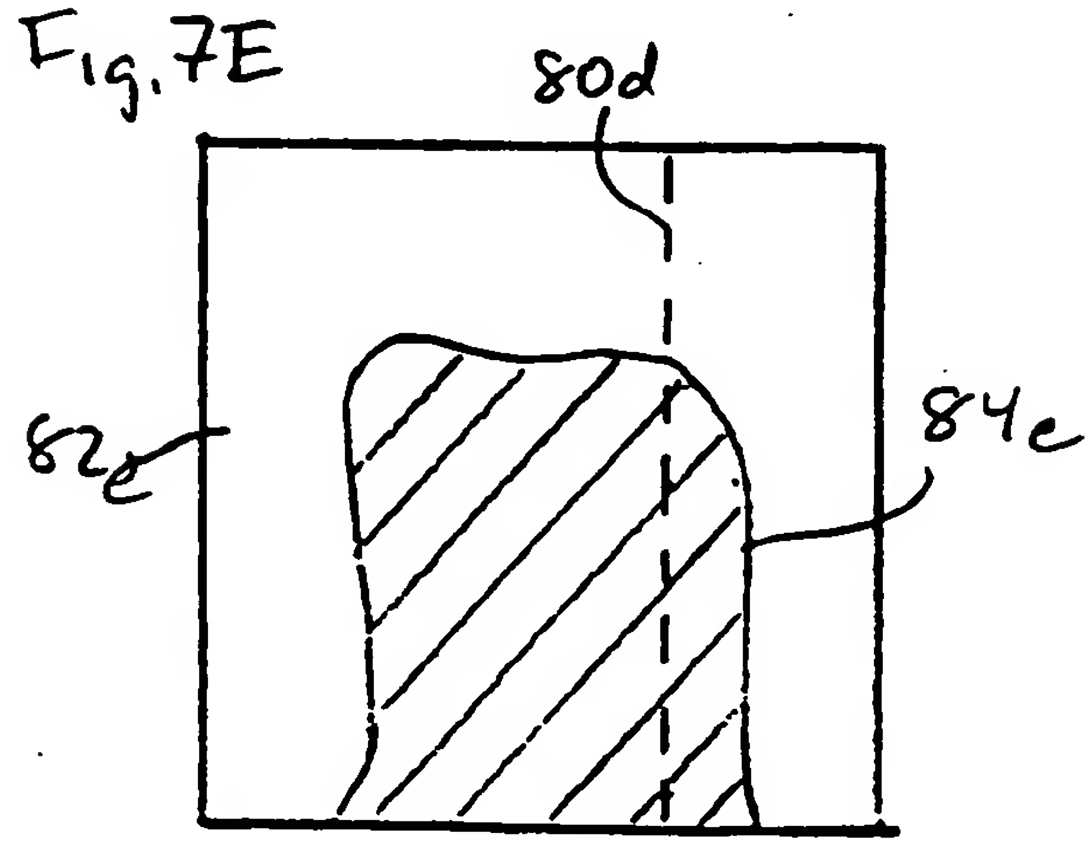


Fig. 7C

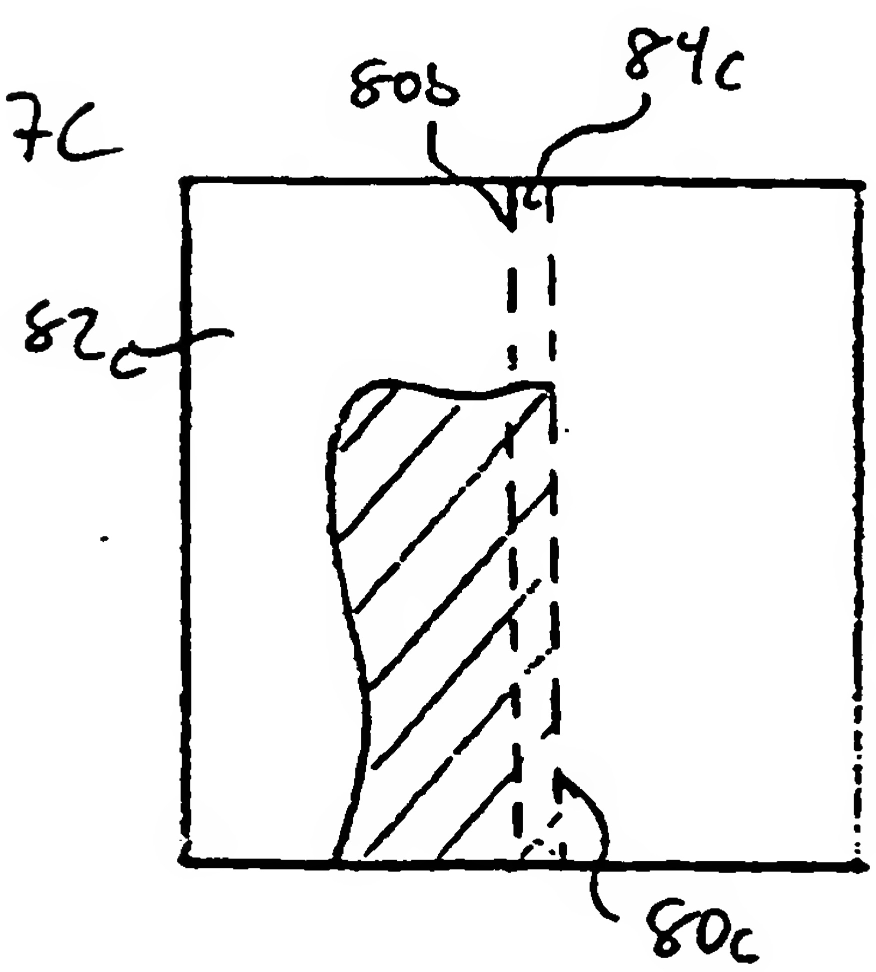


Fig 8A

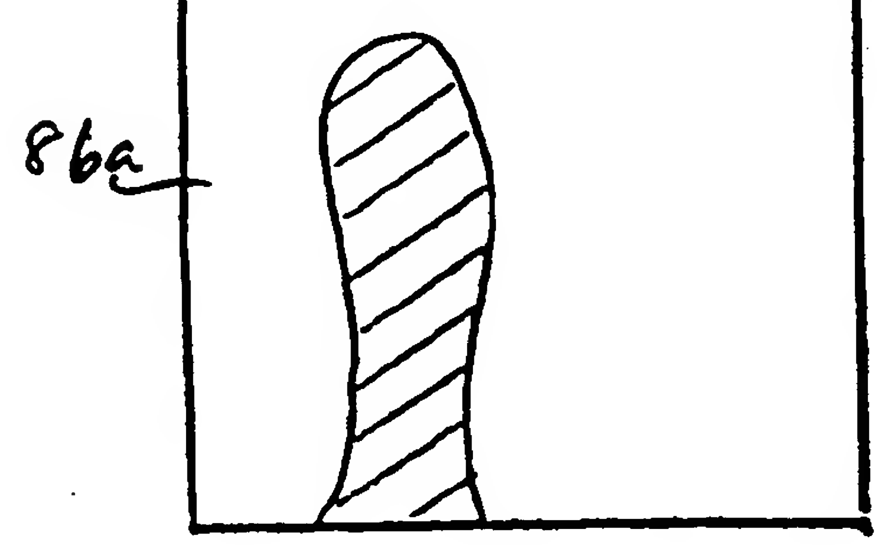


Fig. 8d

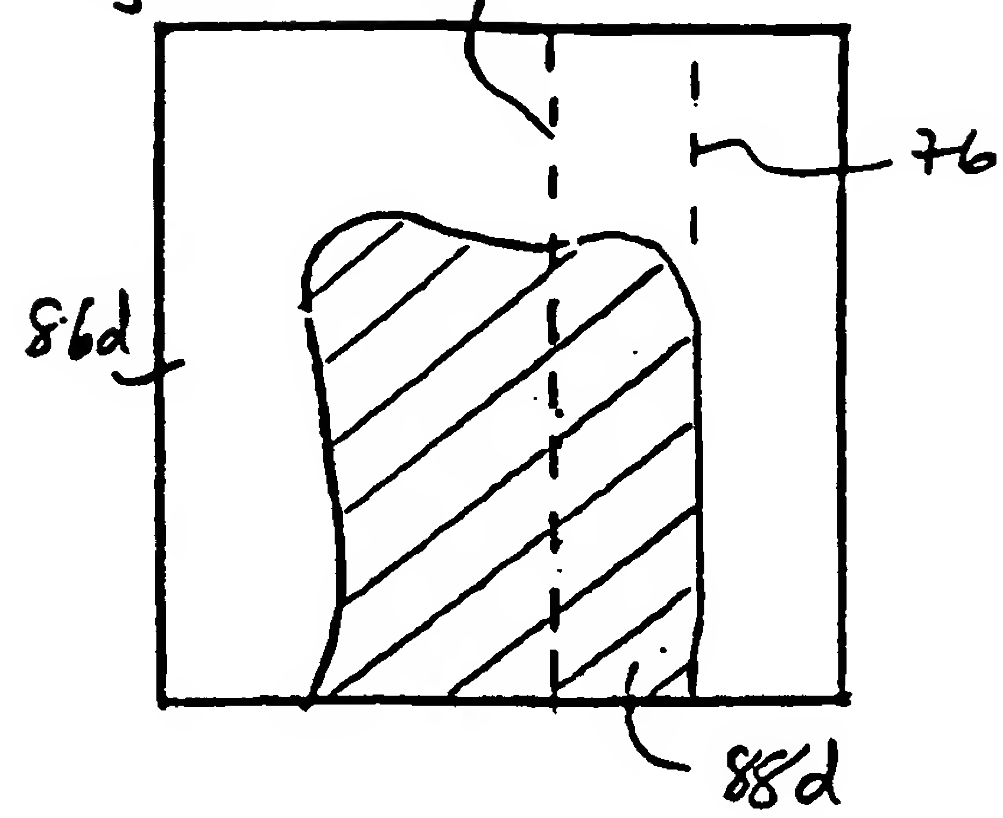


Fig. 8B

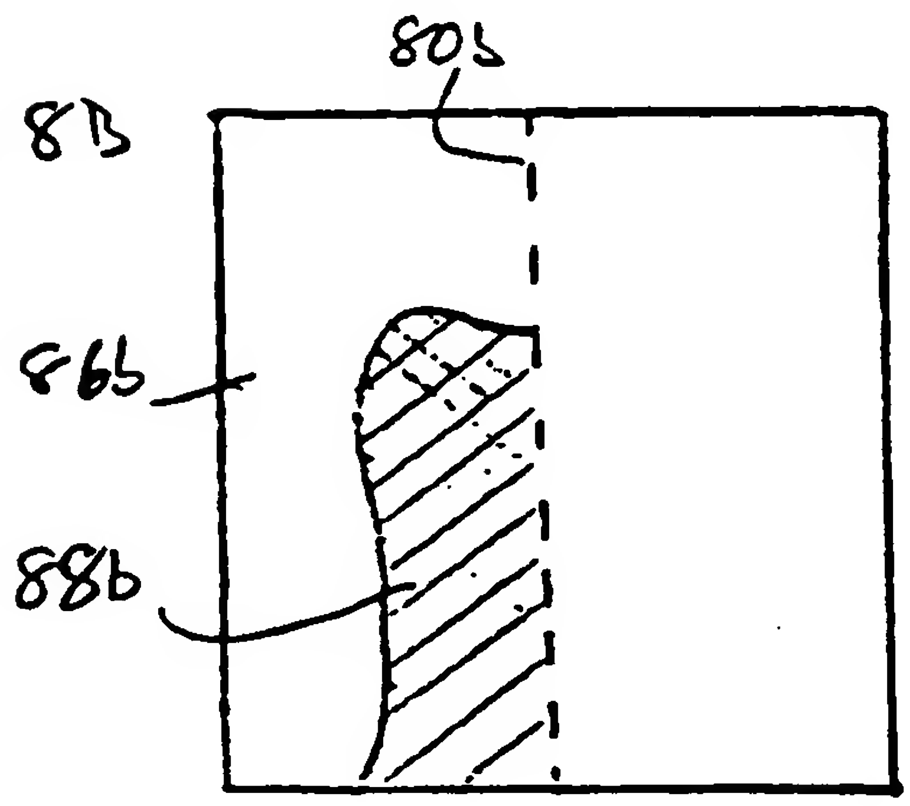


Fig. 8e

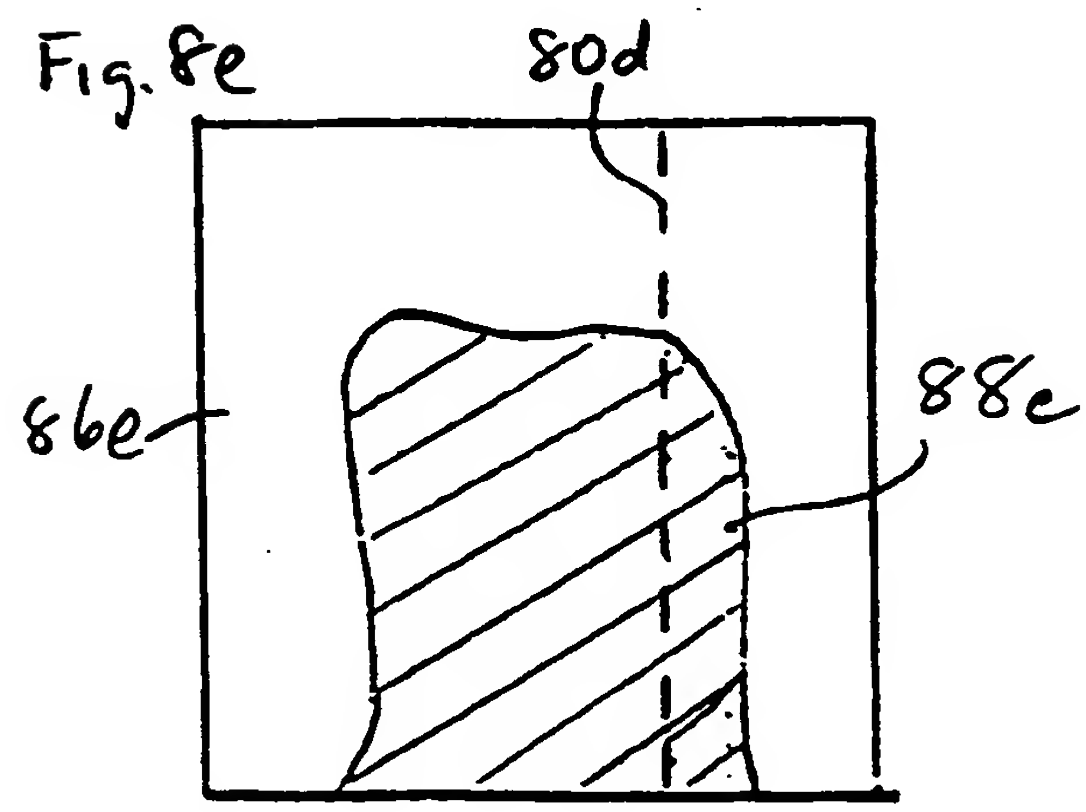
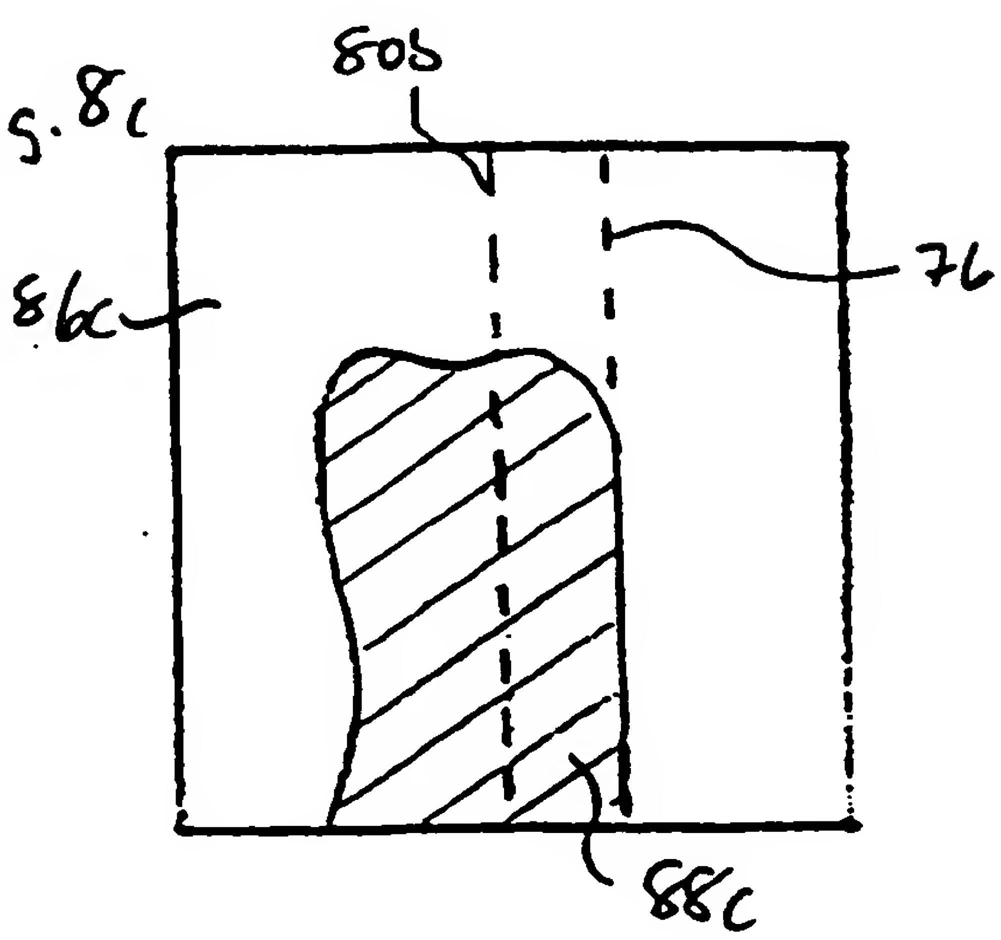


Fig. 8c



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07427

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G06K 9/00; G06K 9/74
US CL :382/124; 356/71
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/124, 125, 126; 356/71

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, MAYA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,230,025 A (FISHBINE ET AL) 20 July 1993, col. 7, lines 14-53	1-22
A	US 4,553,837 A (MARCUS) 19 November 1985.	1-22
A, P	US 5,548,394 A (GILES ET AL) 20 August 1996.	1-22
A	US 4,933,976 A (FISHBINE ET AL) 12 June 1990.	1-22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 JULY 1997	20 AUG 1997

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	BHAVESH MEHTA
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